INSTRUCTION MANUAL

# SYSTEM 816
# MULTI-CHANNEL FILTER

WAVETEK

WAVETEK SAN DIEGO, INC.

9045 Balboa Ave., San Diego, CA 92123

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EFFECTIVITY

Information in this manual is applicable to System 816 mainframes with serial numbers 1233401 and higher, and to System 816 filter cards with serial numbers 1233301 and higher. For mainframes with serial numbers lower than 1233401 the specifications apply only when used with 10 Hz to 150 kHz filter cards. Any changes in design subsequent to the publication of this manual will be documented by addenda shipped with the manual.

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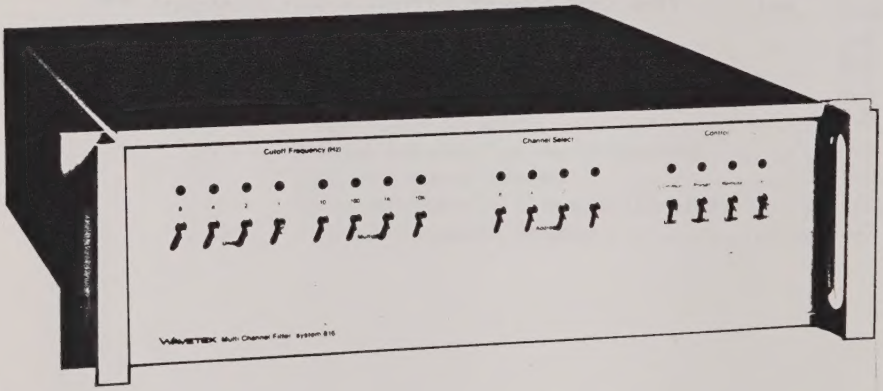



Figure 1-1. System 816 Multi-Channel Filter.

# SECTION I
# GENERAL INFORMATION

## 1-1. INTRODUCTION.

System 816 is a versatile, fully-programmable, multi-channel filter system capable of processing up to 16 independent analog signal channels. Two 48 db/octave responses are available: an 8-pole Butterworth and an 8-pole Bessel. The Butterworth low-pass configuration may be altered to high-pass, and thus, by combining two channels, bandpass and band-reject filters may also be realized.

Among its many applications, System 816 is widely used in spectrum analysis for band-limiting analog signals prior to sampling and analog-to-digital conversion to prevent the "aliasing" of out-of-band components into the frequency band of interest. In this application, as the sampling frequency is changed, the cutoff frequency of the filter is automatically programmed to a corresponding value typically less than half the sampling frequency, to obtain optimum out-of-band signal rejection.

System 816 is ideally suited to automated data acquisition and signal processing in such fields as sonar, vibration, speech, medicine, geophysics, and process control.

System 816 consists of a mainframe and a number of plug-in filter cards. The mainframe provides local, on-card, and remote programming, readout facilities, power, and input/output connections for up to 16 independent channels. One filter card is required for each channel. The user may thus purchase the mainframe and as many filter cards as initially required. System 816 may then be expanded in the future by purchasing additional filter cards.

This manual contains complete specifications, installation and operation instructions, theory of operation, maintenance and calibration procedures, an electrical parts list, and component location and schematic illustrations.

BUTTERWORTH. The Butterworth filter has maximally-flat amplitude response suitable for frequency-domain applications. Its cutoff frequency (fc) is defined as the frequency at which the amplitude response is down 3 db. The attenuation rate (rolloff) beyond the cutoff frequency is 48 db/octave.

BESSEL. The Bessel filter is a linear-phase filter. Because of this characteristic the filter approximates a constant time delay up to its cutoff frequency. This filter is suitable for time-domain applications because of its inherent ability to pass transient waveforms with a minimum of distortion and overshoot. Cutoff frequency (fc) of an 8th-order Bessel filter is defined as the frequency at which the phase shift is equal to 360°; its amplitude response is down 3 db at 0.5 fc.

## 1-2. DESCRIPTION.

ELECTRICAL. System 816 operates from either 115 or 230 volts ac, 50-60 Hz, and consumes 200 watts maximum power. A rear-panel slide switch selects the nominal line voltage. A fan draws air through the instrument for cooling. The case of the instrument is grounded through the power cord, but signal and programming ground is isolated from the case through a .47 uF capacitor. Cutoff frequency is set by an 8-4-2-1 code which selects the units, and a one-of-four decade multiplier. Channel selection is made by 8-4-2-1 code. Filter cards contain two memories, each of which stores the 8 bits necessary to specify the cutoff frequency. One of the memories consists of eight miniature switches mounted on the filter card. By setting these switches to a particular frequency value, a frequently-needed setting is stored in a non-volatile form. The other memory consists of digital registers which can be loaded either by front-panel toggle switches or remote-

programming lines. With PRESET selected (either front panel or programming) the filter cutoff frequency is determined by the on-card switch memory. When PRESET is not selected (NORMAL) the filter cutoff frequency is determined by the data loaded into the digital registers. The cutoff frequency stored in the digital registers can either be loaded into any one selected channel, or into all channels in common. When power to the unit is turned on, the digital registers are automatically loaded to their highest cutoff frequency.

Except for POWER, all controls (CUTOFF FREQUENCY, CHANNEL SELECT, COMMON/LOAD, PRESET/NORMAL, and REMOTE/LOCAL) can be set either by front-panel toggle switches or through programming lines connected to a rear-panel connector. Red light-emitting diodes (LEDs) located above each toggle switch indicate COMMON, PRESET, and/or REMOTE operation, as well as the channel selected at the front panel and the cutoff frequency of that channel.

PHYSICAL. The System 816 cabinet is 5-1/4 inches high by 17 inches wide (19 inches including rack mounts). The instrument is 19 inches deep behind the rack mounts and 20-3/4 inches deep overall. Weight with no filter cards installed is 24-1/2 pounds. Filter cards weigh approximately 1 pound each.

The POWER switch and all operating controls and indicators are located at the front panel. The rear panel contains the fan intake and exhaust vents, power connector and fuse holder, 115/230 VAC line selector switch, one 36-pin programming connector, and two 36-pin signal connectors. The mating connectors for signal and programming are fastened in place when shipped from the factory.

Most of the electrical components are mounted on two printed-circuit boards, in addition to the filter cards. The motherboard holds power supply components and sockets for the plug-in front-panel scanner assembly and all the plug-in filter cards. Etched fingers at the rear of the motherboard accommodate the programming and signal connectors through the rear panel. The scanner assembly, mounted directly behind the front panel, holds the control circuits and the front-panel toggle switches and indicators. The front panel and scanner assembly remove easily for service.

As many as sixteen filter cards can be installed in each System 816 mainframe. Card extractors mounted on each filter card simplify insertion and extraction. Two miniature-switch assemblies, each containing four switches, are mounted on each card for setting PRESET cutoff frequency. These switches are factory-set at their highest frequency value. Eight pairs of miniature plug-in jumpers on Butterworth cards allow the filter cards to be set individually for low-pass or high-pass filtering. Cards are shipped from the factory in low-pass configuration. Bessel cards are hard wired for low-pass filtering only.

## 1-3. OPTIONS.

System 816 filter cards are available in four overlapping frequency ranges. Table 1-1 lists the option numbers for each range for the mainframe and both the Butterworth and Bessel filter cards. The only differences in mainframes are the front-panel MULTIPLIER markings. Cards with different frequency ranges may be used in a common mainframe, but this fact must be suitably noted by the user in his software or operating instructions. The overall frequency range of each of the filter cards consists of four ranges which are selectable by the CUTOFF FREQUENCY controls. (These four ranges are designated A-B-C-D in this manual.) Table 1-2 lists the frequency settings possible with each card. Each option number has four ranges listed below it.

Table 1-1. Frequency Range Options.

| Mainframe | Filter Cards Butterworth | Bessel | Overall Frequency Range |
|---|---|---|---|
| 11 | 01 | 05 | 10 Hz to 150 KHz |
| 12 | 02 | 06 | 1 Hz to 15 KHz |
| 13 | 03 | 07 | 0.1 Hz to 1.5 KHz |
| 14 | 04 | N.A. | 0.01 Hz to 150 Hz |

Table 1-2. Nominal Cutoff Frequency (Hz).

| OPTIONS 01, 05, 11 | | | | | | |
|---|---|---|---|---|---|---|
| OPTIONS 02, 06, 12 | | | | | | |
| OPTIONS 03, 07, 13 | | | | | | |
| OPTIONS 04, 14 | | | | | | |
| 0.01 | 0.1 | 1 | 10 | 100 | 1K | 10K |
| 0.02 | 0.2 | 2 | 20 | 200 | 2K | 20K |
| 0.03 | 0.3 | 3 | 30 | 300 | 3K | 30K |
| 0.04 | 0.4 | 4 | 40 | 400 | 4K | 40K |
| 0.05 | 0.5 | 5 | 50 | 500 | 5K | 50K |
| 0.06 | 0.6 | 6 | 60 | 600 | 6K | 60K |
| 0.07 | 0.7 | 7 | 70 | 700 | 7K | 70K |
| 0.08 | 0.8 | 8 | 80 | 800 | 8K | 80K |
| 0.09 | 0.9 | 9 | 90 | 900 | 9K | 90K |
| 0.10 | 1.0 | 10 | 100 | 1K | 10K | 100K |
| 0.11 | 1.1 | 11 | 110 | 1.1K | 11K | 110K |
| 0.12 | 1.2 | 12 | 120 | 1.2K | 12K | 120K |
| 0.13 | 1.3 | 13 | 130 | 1.3K | 13K | 130K |
| 0.14 | 1.4 | 14 | 140 | 1.4K | 14K | 140K |
| 0.15 | 1.5 | 15 | 150 | 1.5K | 15K | 150K |

## 1-4. SPECIFICATIONS.

Typical Butterworth and Bessel filter characteristics are given in Table 1-3. Figures 1-2 and 1-3 are graphs of typical amplitude and phase responses. Table 1-4 provides operating specifications for System 816.

Table 1-3. Typical Characteristics.

Butterworth Low-Pass Transfer Function:

| Frequency | Amplitude | Phase |
|---|---|---|
| DC | 0 db | 0° |
| $\sqrt{2}/2$ fc | 0 db | -220° |
| fc | -3 db | -360° |
| $\sqrt{2}$ fc | -24 db | -495° |
| 2 fc | -48 db | -570° |

Butterworth High-Pass Response: mirror image of low-pass response except for highest MULTIPLIER range (not recommended for high-pass operation)

Bessel Low-Pass Transfer Function:

| Frequency | Amplitude | Phase |
|---|---|---|
| DC | 0 db | 0° |
| 0.25 fc | -0.7 db | -90° |
| 0.5 fc | -3 db | -180° |
| 0.75 fc | -7 db | -270° |
| fc | -13.6 db | -360° |

| | Butterworth | Bessel |
|---|---|---|
| Peak Overshoot: | 16% | 0.5% |
| Settling Time (plus 3 mSec programming time): | | |
| To $\pm$ 1% of final value | 3.1/fc | 1.6/fc |
| To $\pm$ 0.1% of final value | 5.1/fc | 2.3/fc |
| To $\pm$ 0.01% of final value | 7.1/fc | 3.2/fc |

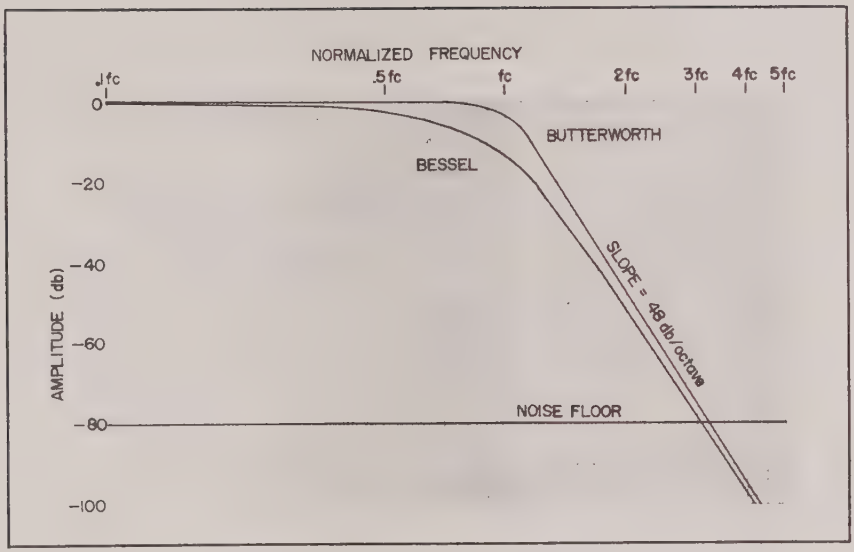



Figure 1-2. Typical Amplitude Response.

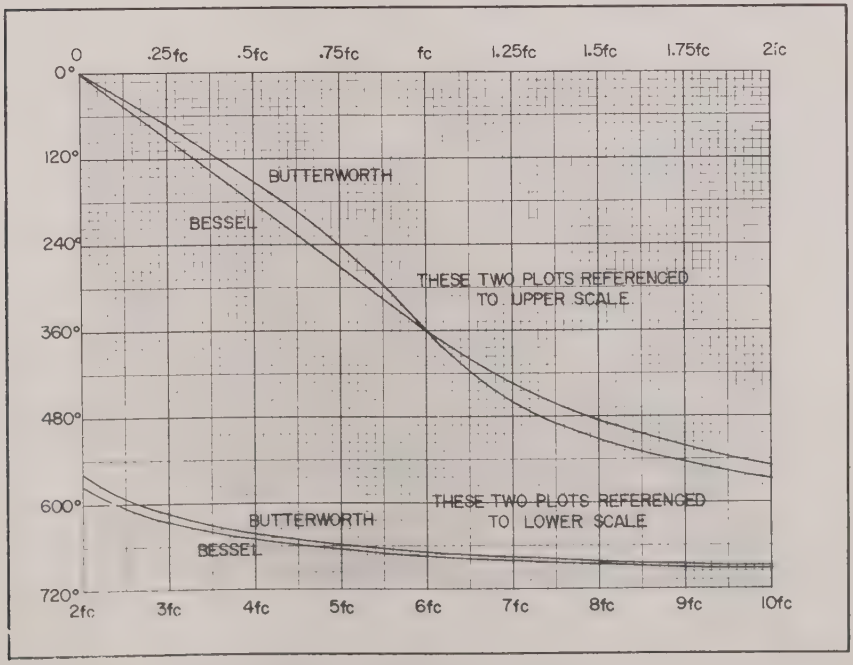



Figure 1-3. Typical Phase Response.

Table 1-4. Specifications.

CUTOFF FREQUENCY

Resolution: cutoff frequency units may be programmed to fifteen discrete values, from 1 to 15

Range: four multiplier ranges may be programmed (see Table 1-1). The cutoff frequency in Hertz is the product of the Units setting and the Multiplier setting.

Accuracy: ± 2% typical, ±3% maximum

Stability: ± 200 ppm/°C

DC GAIN

0 db ± 0.25 db

PHASE MATCH BETWEEN FILTER CARDS

± 2% (typical)

INPUT CHARACTERISTICS

Circuit: single ended, DC isolated from chassis

Impedance: 1 megohm shunted by 50 pF

Full-Scale Signal: ± 10 volts (20 V, pk-pk)

Absolute Maximum Input: ± 100 volts (AC + DC)

OUTPUT CHARACTERISTICS

Circuit: single ended, DC isolated from chassis

Impedance: 50 ohms

Full-Scale Signal: ± 10 volts (20 V, pk-pk)

Output Current: ± 20 mA into 50 ohms (typical)

Distortion: less than 0.1%

Noise and Hum (Including Crosstalk): 80 db below full-scale signal

DC Offset: ± 25 mV at any fc setting

Drift: 0.5 mV/°C

Table 1-4. Specifications (Cont).

REMOTE PROGRAMMING

Requires a maximum of 17 bits (lines) for full programming of the 16-channel system as follows:

Four bits select channel to be programmed

Four bits select cutoff frequency units

Four bits select cutoff frequency range multiplier

One bit each for Device Select, Common Program, Load Command, Preset Command, and Load Acknowledge

All input lines represent two standard TTL loads. Each line is terminated with a 3.3K pull-up resistor to +5 V DC. An unconnected (open) line will assume logic "0" (high)

Inverted TTL Logic Levels:

logic "1" is 0.0 V to +0.8 V (low)

logic "0" is +2.0 V to +5.0 V (high)

Cutoff Frequency Units: four lines, 8-4-2-1 code, selected by logic "1"

Cutoff Frequency Multiplier: four lines, selected by logic "1", weight dependent on frequency range of card being programmed

| | | | | |
|---|---|---|---|---|
| 10 Hz to 150 KHz card | X10 | X100 | X1K | X10K |
| 1 Hz to 15 KHz card | X1 | X10 | X100 | X1K |
| 0.1 Hz to 1.5 KHz card | X0.1 | X1 | X10 | X100 |
| 0.01 Hz to 150 Hz card | X0.01 | X0.1 | X1 | X10 |

If two or more Multiplier values are programmed, the highest programmed value operates.

Channel Select: four lines, 8-4-2-1 code, selected by logic "1"

Device Select: one line, low selects remote-program control, high selects front-panel control

Table 1-4. Specifications (Cont).

Common Program: one line, low allows Load only to channel determined by Channel Select lines, high selects identical loading of all channels

Load Command: one line; normally held high, low loads Cutoff Frequency data. When held high all Cutoff Frequency data which has been loaded is stored internally; programming inputs need not be held constant.

Preset Command: one line; normally held high, low enables on-card cutoff-frequency switch control of fc and disables digital register control of fc (digital registers can still be loaded)

Load Acknowledge (Output): one line, normally high. Pulled low through the collector of an NPN transistor to indicate to the programmer that data has been loaded, and remains low as long as both Device Select and Load Command are low.

Programming Delay: less than 3 mS for any function

ELECTRICAL AND PHYSICAL CHARACTERISTICS

Primary Power: 115 or 230 VAC $\pm$ 10%, 50-60 Hz, 200 watts maximum (with 16 filter cards installed)

Dimensions: cabinet is 5-1/4 inches (13.3 cm) high, 17 inches (43.2 cm) wide, 19 inches (48.3 cm) deep; mounts in standard RETMA rack. Depth behind rack mount is 19 inches (48.3 cm) including rear-panel components.

Weight: mainframe, 24-1/2 lb (11.14 kg); filter cards, each 1 lb (0.45 kg)

Operating Temperature: 0°C to +50°C ambient

Storage Temperature: -20°C to +70°C

Connectors: all input, output, and programming connections are made at the rear panel via three p.c.-edge connectors. Mating connectors (CINCH-JONES No. 50-36A-30) are supplied with the mainframe.

# SECTION II

# OPERATION

## 2-1. INTRODUCTION.

System 816 is electrically operational as shipped from the factory. The following paragraphs describe inspection, power requirements, interconnection, and operation.

## 2-2. INSPECTION.

This system was carefully inspected and tested prior to shipment. It was operated for a number of hours to reduce the probability of early failure. After unpacking the unit, it should be carefully inspected for shipping damage. Check especially for broken controls and connectors, and dented or scratched cabinet parts. Should the instrument show any signs of damage, file a claim with the carrier immediately. Preserve the carton and packing materials; they will be required by the carrier.

It is recommended that conformance to specifications be verified upon receipt. In case of discrepancies, refer to the warranty at the beginning of this manual.

## 2-3. INSTALLATION AND POWER REQUIREMENTS.

System 816 is designed primarily for installation in a standard 19-inch RETMA rack. Depth of the rack should be at least 22 inches to allow 3 inches minimum behind the instrument for cables and ventilation. Ambient temperature within the rack must not exceed +50°C while the instrument is operating. Other paragraphs in this section describe connections and switch settings which should be made before the unit is installed.

CAUTION

Always ensure that the 115/230 volt switch is set for the nominal line voltage and that a fuse of the proper

rating is installed in the instrument. If the switch is set incorrectly or a fuse of the wrong rating is used, the instrument may be damaged or fail to operate.

The instrument will operate from either 115 or 230 volts ac, 50-60 Hz. Conversion for line voltage is performed with a slide switch mounted on the rear panel (see Figure 2-1). The unit is shipped with the switch set for 115 volts. To change the setting, insert a small-blade screwdriver in the switch slot and move switch to expose 115 for 115 Vac operation, or 230 for 230 Vac operation.

The instrument is shipped with a 2-amp slow-blow fuse for 115-volt operation. If the unit is to be operated from a 230-volt supply, the fuse should be replaced with a 1-amp slow-blow fuse (not supplied).

WARNING

In keeping with standard safety practice, the case of the instrument is grounded through the power cord. If the instrument must be connected to a two-wire receptacle, use a parallel-ground adapter and connect the short lead to ground.

## 2-4. CONTROLS AND INDICATORS.

System 816 controls and indicators are shown in Figure 2-1 and described in Table 2-1. The descriptions in Table 2-1 and the following paragraphs are not intended to be complete operating instructions, but only general information applying to all modes of operation. Paragraphs 2-5, 2-6, and 2-7 describe filter-card settings, interconnection, and typical operating procedures.

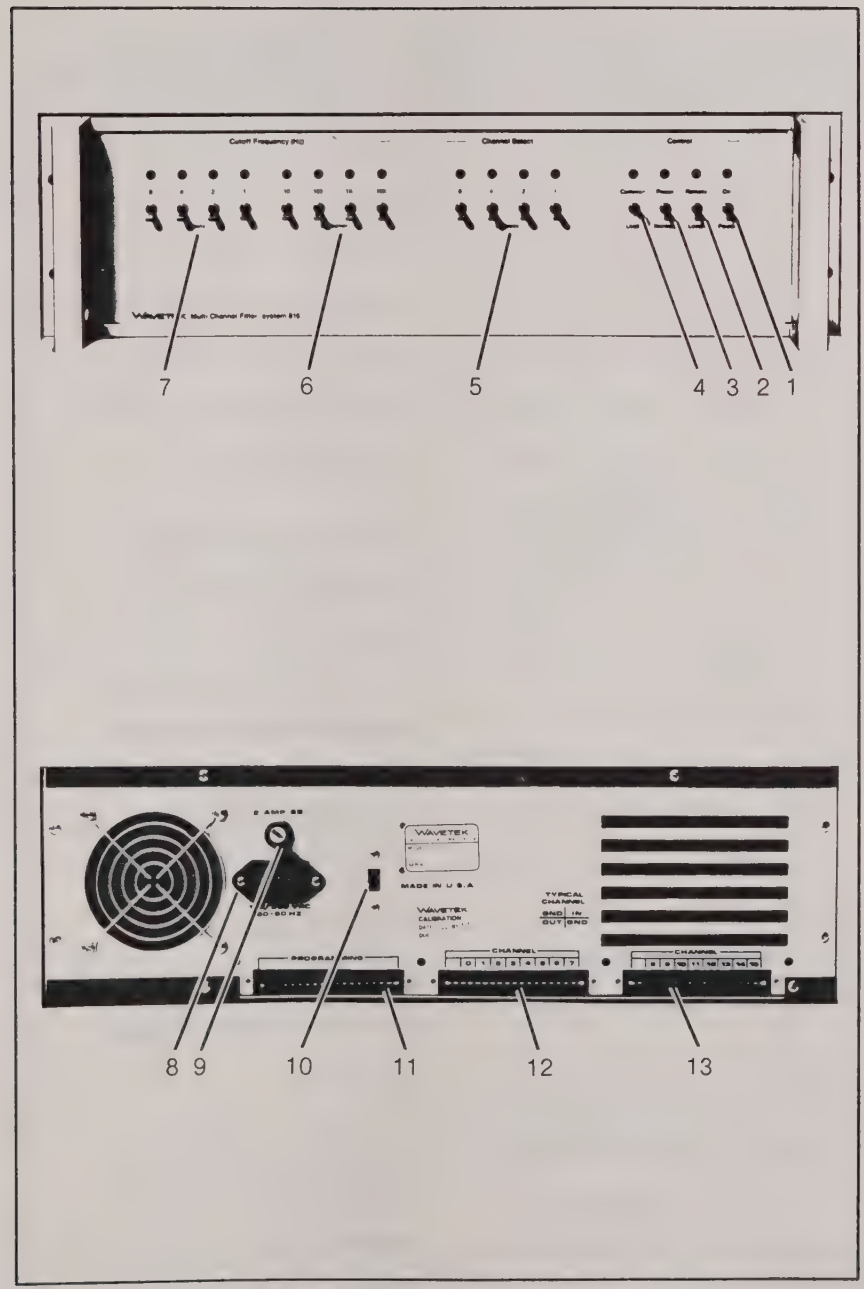



Figure 2-1. Controls And Indicators.

Table 2-1. Controls And Indicators.

| NUMBER | ITEM | DESCRIPTION |
|---|---|---|
| 1 | POWER ON Switch | A two-position toggle switch which supplies power to the instrument. The digital register memories on all filter cards are loaded to their highest cutoff-frequency value when power is turned on. A red light-emitting diode (LED) located above the switch indicates that power is on. |
| 2 | LOCAL/REMOTE Switch | A two-position toggle switch; in LOCAL the unit is controlled by front-panel switches, in REMOTE the unit is controlled by programming commands through the rear-panel PROGRAMMING Connector. With this switch at LOCAL, remote control can still be selected via the PROGRAMMING Connector. A red LED indicates REMOTE control, whether selected at the front panel or remotely. |
| 3 | NORMAL/PRESET Switch | A two-position toggle switch; in NORMAL the cutoff frequency is controlled by digital registers on each filter card. These registers can be |

Table 2-1. Controls And Indicators (Cont).

| NUMBER | ITEM | DESCRIPTION |
|---|---|---|
| | | loaded either by front-panel switches or remote-programming lines. In PRESET the cutoff frequency is set by switches on each filter card. A frequently-used program can be stored with the on-card switches, eliminating the need to reprogram the digital register each time the instrument is turned on. With switch at NORMAL, PRESET can still be selected via the PROGRAMMING Connector. A red LED indicates PRESET operation, whether selected at the front panel or remotely. |
| 4 | LOAD/COMMON Switch | A three-position toggle switch, normally in the middle (off) position. In the momentary-contact LOAD position cutoff-frequency data is loaded into the digital register of a single selected channel. In COMMON, all channels are loaded at the same time; the digital registers follow the front-panel switch settings as long as the switch is left in COMMON. A red LED indicates COMMON. |

Table 2-1. Controls And Indicators (Cont).

| NUMBER | ITEM | DESCRIPTION |
|---|---|---|
| 5 | CHANNEL SELECT Switches | Four two-position toggle switches which select the channel (0-15) whose cutoff frequency is to be set by a front-panel LOAD command. In REMOTE (or LOCAL) operation, the cutoff frequency displayed on the front panel is that of the channel selected by the CHANNEL SELECT Switches. Four red LEDs indicate the address of the selected channel in 8-4-2-1 code. |
| 6 | CUTOFF FREQUENCY MULTIPLIER Switches | Four two-position toggle switches which select one of four overlapping frequency ranges. If more than one multiplier is selected, only the highest selected value operates (see Table 2-2). Four red LEDs indicate the range of the filter card selected by the CHANNEL SELECT Switches, whether that range is set by the on-card switches, at the front panel, or remotely. |

Table 2-1. Controls And Indicators (Cont).

| NUMBER | ITEM | DESCRIPTION |
|---|---|---|
| 7 | CUTOFF FREQUENCY UNITS Switches | Four two-position toggle switches which select the units of the cutoff frequency in Hertz (see Table 2-2). Four red LEDs indicate the cutoff frequency units (in 8-4-2-1 code) of the filter card selected by the CHANNEL SELECT Switches, whether that value is set by the on-card switches, at the front panel, or remotely. |
| 8 | Power Connector | Supplies primary power and grounds the chassis of the instrument. |
| 9 | Fuse Holder | Holds power-line fuse; 2-amp slow-blow for 115 V, 1-amp slow-blow for 230 V. |
| 10 | 115/230 Volt Switch | Sets the instrument for the nominal line voltage. |
| 11 | PROGRAMMING Connector | A 36-pin connector used to connect programming signals to System 816 (see Table 2-5). |
| 12 & 13 | CHANNEL Connectors | Two 36-pin connectors used to make signal input and output connections (see Tables 2-3 and 2-4). |

CHANNEL SELECTION. Channels are numbered 0 through 15, and are selected in 8-4-2-1 code as shown in Table 2-2a.

CUTOFF FREQUENCY SETTING. Table 2-2 lists the codes which select the CUTOFF FREQUENCY UNITS and MULTIPLIER. In LOCAL (front-panel) control, "1" is selected by setting the toggle switch to its upper position, toward the selected unit or multiplier range. Tables 1-3 and 2-5 provide data concerning the signal levels of the "1" (active) state for REMOTE control.

NOTES

A UNITS value of "0" (zero) should be avoided. Selecting a UNITS value of "0" will saturate the filter amplifiers.

It is recommended that the highest MULTIPLIER range (D) not be used in high-pass configuration.

It can be seen from Table 2-2 that if more than one multiplier range is selected, either at the front panel or remotely, only the highest selected range operates. This means that two ranges can be controlled by one switch or programming line. For example, selection between the B and D ranges can be made by selecting both ranges. When D range is needed, leave both ranges on, and only the D range operates. When B range is needed, simply turn the D range off and B range will then operate.

NOTE

Only one MULTIPLIER range may be selected by the on-card PRESET Switches. The other three ranges must be turned off.

Table 2-2. CUTOFF FREQUENCY And CHANNEL SELECT Switch Settings.

a. CUTOFF FREQUENCY UNITS And CHANNEL SELECT

| CHANNEL | CUTOFF FREQUENCY (Hz) UNITS | CODE 8-4-2-1 |
|---|---|---|
| 0 | AVOID | 0 0 0 0 |
| 1 | 1 | 0 0 0 1 |
| 2 | 2 | 0 0 1 0 |
| 3 | 3 | 0 0 1 1 |
| 4 | 4 | 0 1 0 0 |
| 5 | 5 | 0 1 0 1 |
| 6 | 6 | 0 1 1 0 |
| 7 | 7 | 0 1 1 1 |
| 8 | 8 | 1 0 0 0 |
| 9 | 9 | 1 0 0 1 |
| 10 | 10 | 1 0 1 0 |
| 11 | 11 | 1 0 1 1 |
| 12 | 12 | 1 1 0 0 |
| 13 | 13 | 1 1 0 1 |
| 14 | 14 | 1 1 1 0 |
| 15 | 15* | 1 1 1 1 |
| | *This setting should also be used when the filter is operated as a DC Amplifier | |

b. CUTOFF FREQUENCY MULTIPLIER

| CUTOFF FREQUENCY (Hz) MULTIPLIER | CODE |
|---|---|
| DC AMPLIFIER* | 0 0 0 0 |
| A | 0 0 0 1 |
| B | 0 0 1 X |
| C | 0 1 X X |
| D** | 1 X X X |

X=either 0 or 1 except for the on-card PRESET Switches. For these switches only one range can be selected, the others must be switched off.

* Filter cards may be operated as DC Amplifiers only in low-pass configuration, avoid this setting in high-pass configuration.

** Avoid this setting in high-pass configuration.

Certain values of cutoff frequency can be obtained by either of two combinations of switch settings. For instance, 1 KHz can be obtained with a UNITS value of 1 and a range MULTIPLIER of X1000, or with a UNITS value of 10 and a range MULTIPLIER of X100. Generally it is recommended to use the higher UNITS value and the lower MULTIPLIER (UNITS of 10, MULTIPLIER of X100 in this example).

SETTLING TIME. The longest settling time of the filters occurs when switching to the lowest MULTIPLIER range (A). To obtain fastest settling when switching to a lower MULTIPLIER, proceed as follows:

1. Select desired MULTIPLIER range.
2. Temporarily select a UNITS value of 15.
3. Select desired UNITS value.

SPECIAL MODES. Filter bypass can be obtained by selecting no MULTIPLIER range. In this configuration the filter operates as a DC amplifier with unity gain. A UNITS value of 15 should be selected to minimize noise pickup. Either Butterworth or Bessel filter cards can be used as DC amplifiers, but the Butterworth card must be set for low-pass operation.

INDICATORS. The LEDs above the CUTOFF FREQUENCY toggle switches indicate the cutoff frequency of the channel selected by the front-panel toggle switches. Therefore, changing the CUTOFF FREQUENCY Switches will not affect the cutoff frequency (hence, the LEDs) until receipt of a LOAD Command or unless COMMON is selected. The LEDs will not light if there is no filter card in the selected channel.

The LEDs above the CHANNEL SELECT Switches indicate the address of the channel selected by the front-panel switches only.

## 2-5. FILTER CARD SETTINGS AND INSTALLATION.

ON-CARD CUTOFF FREQUENCY SWITCHES. Figure 2-2 shows the location of the on-card switches which set the cutoff frequency in PRESET mode. Cards are shipped with a units value of 15 and the highest multiplier range selected.

To set the units, slide the switches to the right to select units from 1 to 15 as required. The example in Figure 2-2b shows a units value of 13 selected; the 8, 4, and 1 switches are set to the right, toward the numbers etched on the printed-circuit board.

To set the multiplier, set the desired switch to the left, toward the multiplier range value printed on the label to the left of the switches. The example in Figure 2-2a shows a multiplier value of X100 selected on a filter card having an overall frequency range of 10 Hz to 150 KHz. Filter cards in other frequency ranges have labels which correspond to the range of the card. Unlike operation in LOCAL and REMOTE modes, only one multiplier range may be selected; the other ranges must be turned off.

LOW PASS/HIGH PASS JUMPERS. On Butterworth filter cards eight pairs of plug-in jumpers on each card determine low-pass or high-pass operation. (Cards are shipped in low-pass configuration. Bessel filter cards are hard-wired for low-pass operation only.) Figure 2-3 shows the locations of the jumpers. Each jumper set consists of five jacks soldered to the filter card in a "W"-shaped pattern, and two jumper plugs. For explanation purposes, the pins are designated a, b, c, d, e in Figure 2-3a. For low-pass operation, connect pin a to pin c and pin b to pin d. For high-pass operation, connect pin a to pin d and pin b to pin a.

NOTE

All eight jumper sets on any one card must be set in the same way, either low-pass or high-pass.

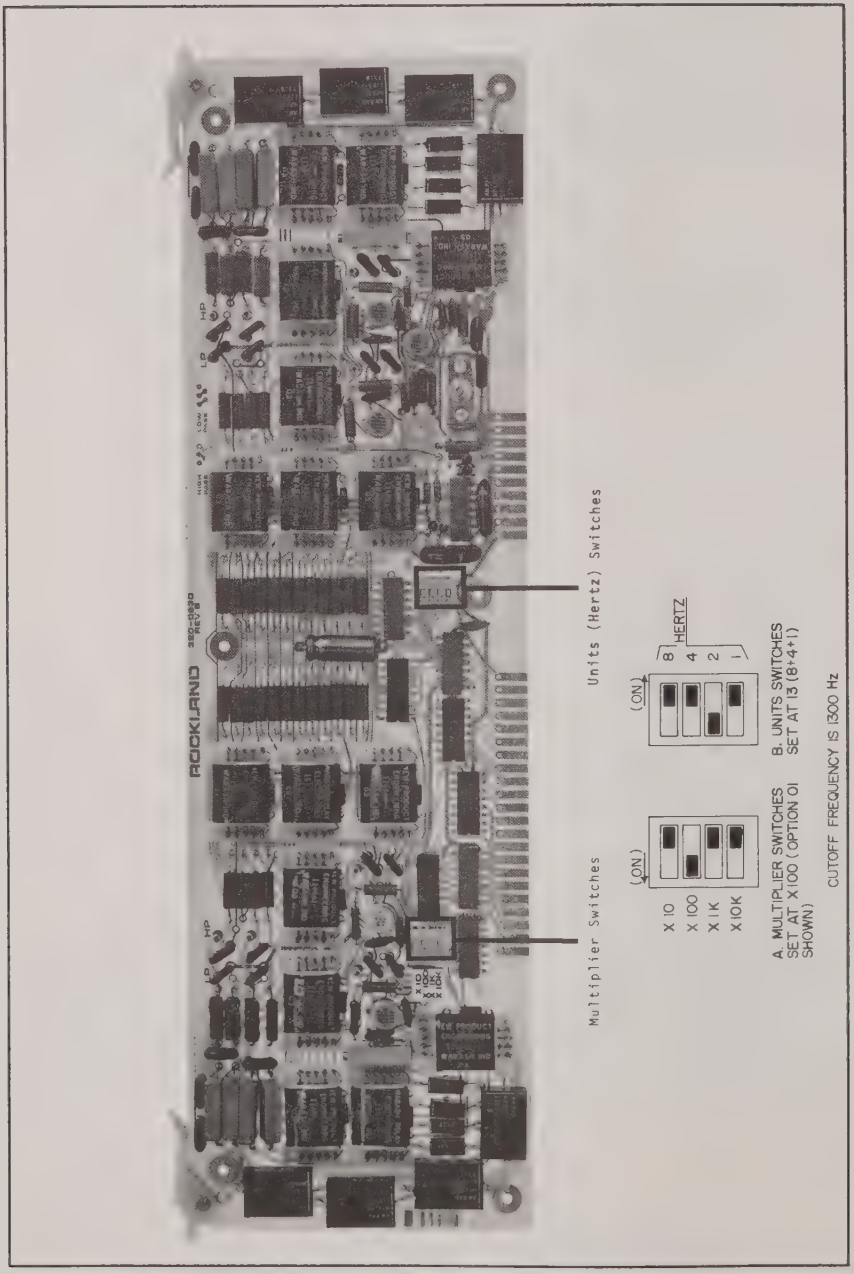



Figure 2-2. On-Card (Preset) Cutoff Frequency Switches.

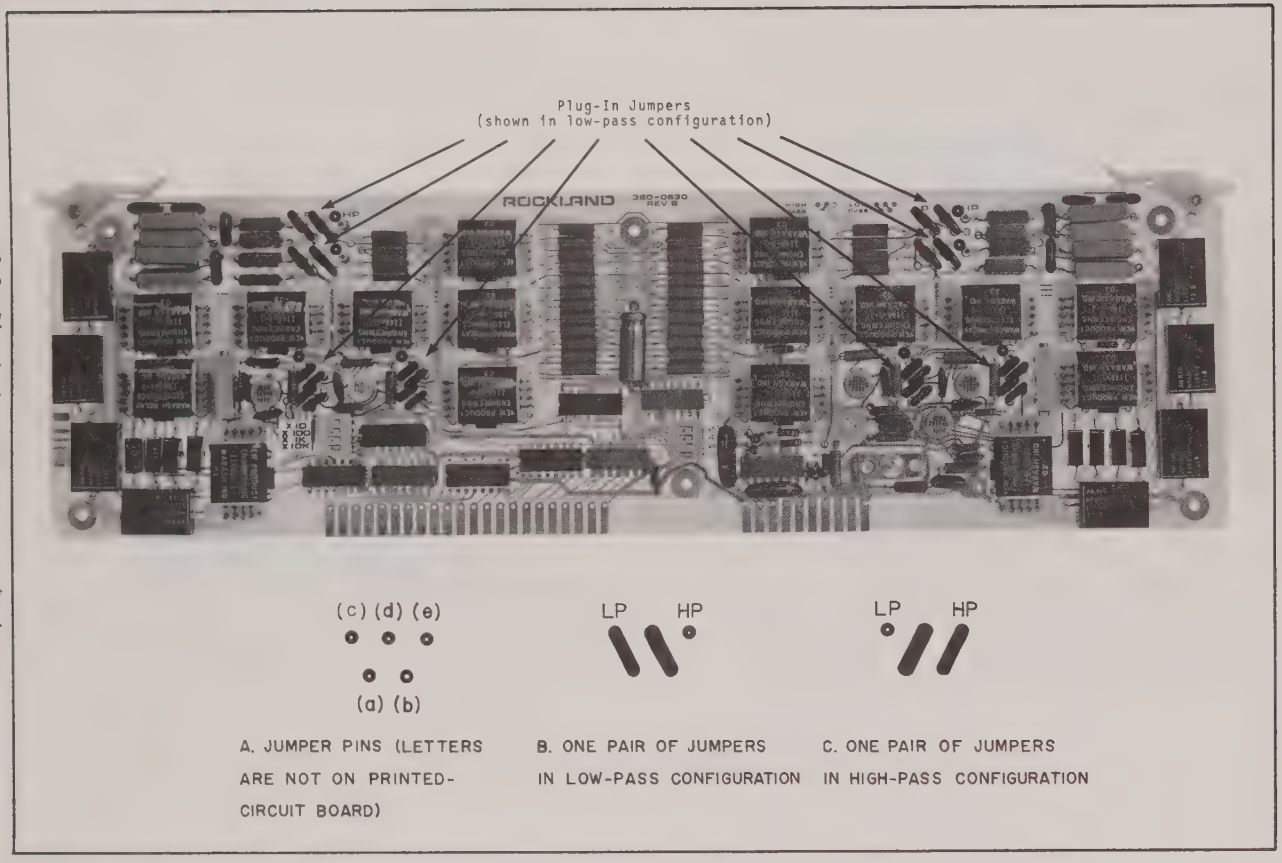

Plug-In Jumpers
(shown in low-pass configuration)
ROCKLAND
(c) (d) (e)
(a) (b)
LP HP
LP HP
A. JUMPER PINS (LETTERS ARE NOT ON PRINTED-CIRCUIT BOARD)
B. ONE PAIR OF JUMPERS IN LOW-PASS CONFIGURATION
C. ONE PAIR OF JUMPERS IN HIGH-PASS CONFIGURATION

Figure 2-3. Plug-In Jumpers For Low Pass/High Pass.

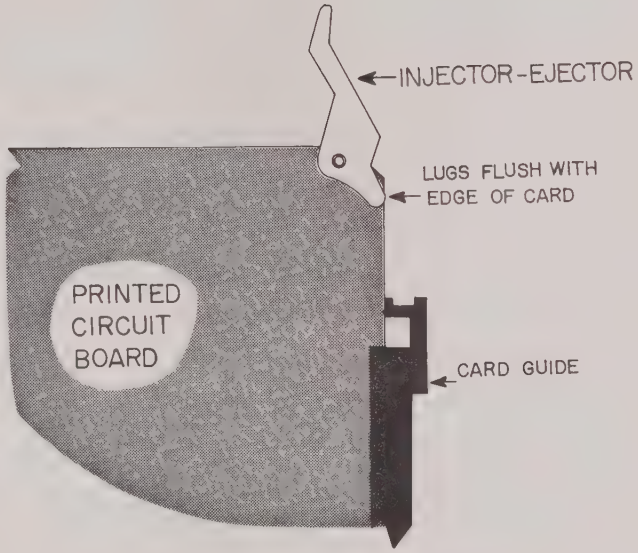
INSTALLATION.

WARNING

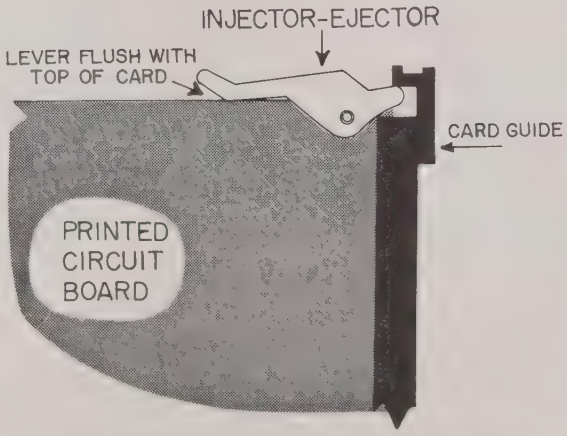
Exposed electrical connections within the instrument may connect to potentially dangerous voltages, even when the POWER Switch is turned off. Exercise caution when working within any electrical equipment.

Filter Cards are installed with the component side facing to the right of the instrument. Channel numbers are etched on the motherboard adjacent to the rear socket for each filter card. A filter card may be installed in any channel; cards need not be installed sequentially. To install filter cards in System 816, proceed as follows (see Figure 2-4):

1. Remove two screws which secure the top cover to the rear panel, and slide the top cover to the rear.
2. Position injector-ejectors on each side of card so that engaging lugs are flush with side edge of card (Figure 2-4a).
3. Slide card into guide slots for desired channel.
4. Ensure that printed-circuit board contacts are properly aligned with both sockets on the motherboard.
5. Push both injector-ejector levers down at the same time to lock the card in place (Figure 2-4b). With the levers flush with the top of the card, press down on both injector-ejectors to ensure that card is fully seated.
6. To remove a card, pull both injector-ejector levers up at the same time to unseat the card.




a. Injector-Ejector Set for Insertion.




b. Filter Card Locked in Place.

Figure 2-4. Filter Card Installation.

## 2-6. INTERCONNECTION.

SIGNAL. All input and output signal connections are made through two rear-panel connectors. The connectors are printed-circuit edge type, with 18 contacts on the top edge, and 18 on the bottom. Input signal and ground lines alternate on the top row, and output signal and ground lines alternate on the bottom row. Table 2-3 lists the pin connections for the CHANNEL 0-7 Connector, and Table 2-4 lists the pin connections for the CHANNEL 8-15 Connector. Pin designations are, from left to right, 1 to 18 on the top row and A to V on the bottom row.

Signal connections should generally be made with coaxial cable, with the cable shield soldered to the ground pin next to the signal pin. In some applications, where crosstalk or noise pickup is not a serious consideration, twisted pairs may be adequate for signal connections.

PROGRAMMING. Remote programming controls are supplied to System 816 at the rear panel through a printed-circuit edge connector. The connector has two rows of 18 contacts, designated from left to right. The top row of contacts, pins 1 through 18, is used for the programming input and output signals. Programming ground connections are made at any or all of the bottom row of contacts, pins A through V. Table 2-5 lists the pin connections for the PROGRAMMING Connector and provides a description of each signal. Remote programming inputs are low active ("1" state). A "1" is 0V to 0.8V, and a "0" is +2V to +5V.

Programming connections should generally be made through twisted pairs of leads to prevent false data from being loaded through coupling between lines. All the ground lines can be tied together at the programming instrument if necessary. In some applications, with short lead lengths (generally less than 2 feet), twisted pairs may not be necessary.

Cable clamps supplied with the unit may be used to support signal and programming cables.

Table 2-3. CHANNEL 0-7 Signal Connector.

| PIN | DESCRIPTION | PIN | DESCRIPTION |
|---|---|---|---|
| 1 | No Connection | A | No Connection |
| 2 | No Connection | B | No Connection |
| 3 | Channel 0 Ground (Input) | C | Channel 0 Output |
| 4 | Channel 0 Input | D | Channel 0 Ground (Output) |
| 5 | Channel 1 Ground (Input) | E | Channel 1 Output |
| 6 | Channel 1 Input | F | Channel 1 Ground (Output) |
| 7 | Channel 2 Ground (Input) | H | Channel 2 Output |
| 8 | Channel 2 Input | J | Channel 2 Ground (Output) |
| 9 | Channel 3 Ground (Input) | K | Channel 3 Output |
| 10 | Channel 3 Input | L | Channel 3 Ground (Output) |
| 11 | Channel 4 Ground (Input) | M | Channel 4 Output |
| 12 | Channel 4 Input | N | Channel 4 Ground (Output) |
| 13 | Channel 5 Ground (Input) | P | Channel 5 Output |
| 14 | Channel 5 Input | R | Channel 5 Ground (Output) |
| 15 | Channel 6 Ground (Input) | S | Channel 6 Output |
| 16 | Channel 6 Input | T | Channel 6 Ground (Output) |
| 17 | Channel 7 Ground (Input) | U | Channel 7 Output |
| 18 | Channel 7 Input | V | Channel 7 Ground (Output) |

Table 2-4. CHANNEL 8-15 Signal Connector.

| PIN | DESCRIPTION | PIN | DESCRIPTION |
|---|---|---|---|
| 1 | No Connection | A | No Connection |
| 2 | No Connection | B | No Connection |
| 3 | Channel 8 Ground (Input) | C | Channel 8 Output |
| 4 | Channel 8 Input | D | Channel 8 Ground (Output) |
| 5 | Channel 9 Ground (Input) | E | Channel 9 Output |
| 6 | Channel 9 Input | F | Channel 9 Ground (Output) |
| 7 | Channel 10 Ground (Input) | H | Channel 10 Output |
| 8 | Channel 10 Input | J | Channel 10 Ground (Output) |
| 9 | Channel 11 Ground (Input) | K | Channel 11 Output |
| 10 | Channel 11 Input | L | Channel 11 Ground (Output) |
| 11 | Channel 12 Ground (Input) | M | Channel 12 Output |
| 12 | Channel 12 Input | N | Channel 12 Ground (Output) |
| 13 | Channel 13 Ground (Input) | P | Channel 13 Output |
| 14 | Channel 13 Input | R | Channel 13 Ground (Output) |
| 15 | Channel 14 Ground (Input) | S | Channel 14 Output |
| 16 | Channel 14 Input | T | Channel 14 Ground (Output) |
| 17 | Channel 15 Ground (Input) | U | Channel 15 Output |
| 18 | Channel 15 Input | V | Channel 15 Ground (Output) |

Table 2-5. PROGRAMMING Connector.

| FUNCTION | PIN | DESCRIPTION |
|---|---|---|
| Channel Select 1 | 1 | Low active. Select the channel (0-15), in 8-4-2-1 code, whose cutoff frequency is to be programmed. (The CHANNEL SELECT Indicators are always controlled by the front-panel CHANNEL SELECT Switches.) |
| Channel Select 2 | 3 | |
| Channel Select 4 | 5 | |
| Channel Select 8 | 7 | |
| Cutoff Frequency 1 | 10 | Low active. Select the cutoff-frequency units (Hertz) in 8-4-2-1 code. The code for 0 is meaningless, and should be avoided. |
| Cutoff Frequency 2 | 11 | |
| Cutoff Frequency 4 | 12 | |
| Cutoff Frequency 8 | 13 | |
| Multiplier A | 14 | Low active. Select the cutoff-frequency range multiplier. The weights of A-B-C-D are in a 1-10-100-1000 ratio (see Tables 1-1, 1-2, and 1-4). If no multiplier is selected, the unit operates as a dc amplifier (low-pass configuration only). |
| Multiplier B | 15 | |
| Multiplier C | 16 | |
| Multiplier D | 17 | |
| Device Select | 2 | Low active. Enables remote programming independently of the front-panel LOCAL/REMOTE Switch. If left high (open), Remote can still be selected by the LOCAL/REMOTE Switch. The REMOTE Indicator indicates remote control, whether selected by the Device Select line or LOCAL/REMOTE Switch. |

Table 2-6. PROGRAMMING Connector (Cont).

| FUNCTION | PIN | DESCRIPTION |
|---|---|---|
| Preset | 4 | Low active. Disables cutoff-frequency data set at the front panel or remotely, and enables cutoff-frequency data set by on-card switches. If left high (open), Preset can still be selected by the NORMAL/PRESET Switch. The PRESET Indicator indicates Preset, whether selected by the Preset line or NORMAL/PRESET Switch. |
| Common Program | 6 | High active. Allows cutoff-frequency data to be loaded into all channels simultaneously upon receipt of a Load Command. If held low (ground), the Load Command loads data only into the channel selected by the Channel-Select lines. The COMMON Indicator will light only for the duration of Load Command. |
| Load Command | 8 | Low active. Loads cutoff-frequency data (units and multiplier) into the digital register of either the selected channel or all channels as determined by Common Program. Cutoff-frequency data is stored while Load Command is high. |
| Load Acknowledge | 9 | Low active. This output line, normally high, is pulled low to signal the programmer that data has been loaded; remains low as long as both Device Select and Load Command are active. |

NOTE: "Low active" is ground, "high active" is open. Programming ground connections are made on the bottom row of contacts, pins A through V. Both programming and ground connections should be made through A.W.G. #26 wire, or heavier.

## 2-7. TYPICAL OPERATING PROCEDURES.

OPERATING MODE SELECTION. System 816 operating mode is controlled by two functions, NORMAL/PRESET, and LOCAL/REMOTE (see Table 2-6). Selection of NORMAL or PRESET determines the source of the cutoff frequency operating on the filter card. When NORMAL is selected, fc is determined by the digital registers on each filter card. When PRESET is selected, fc is determined by the miniature switches mounted on each filter card. PRESET can be selected either by the front-panel NORMAL/PRESET Switch or through the PROGRAMMING Connector. The front-panel PRESET Indicator will light whenever PRESET is enabled, either at the front panel or remotely.

Selection of LOCAL or REMOTE determines the input source for the digital registers on each card. When LOCAL is selected, fc data is loaded into the digital registers from the front-panel CUTOFF FREQUENCY Switches. The channel to be loaded is addressed by the front-panel CHANNEL SELECT Switches. When REMOTE is selected, fc data is loaded into the digital registers through eight PROGRAMMING lines, four to select the UNITS in 8-4-2-1 code, and four to select one of four MULTIPLIER ranges. The channel to be loaded is addressed through four PROGRAMMING lines in 8-4-2-1 code. REMOTE can be selected either by the front-panel LOCAL/REMOTE Switch or through the PROGRAMMING Connector. The front-panel REMOTE Indicator will light whenever REMOTE is enabled, either at the front panel or remotely.

Table 2-6. Operating-Mode Control.

| Source Of Operating fc | | | | Digital Register Input Source | | |
|---|---|---|---|---|---|---|
| Mode | NORMAL/ PRESET Switch | PRESET Line | | Mode | LOCAL/ REMOTE Switch | DEVICE SELECT Line |
| Preset | PRESET | X | | Remote | REMOTE | X |
| | X | Low | | | X | Low |
| Normal | NORMAL | High | | Local | LOCAL | High |
| X indicates that setting is irrelevant. | | | | | | |

In REMOTE mode, cutoff frequency data on the PROGRAMMING lines is loaded upon receipt of a Load Command (0.1uS minimum duration). With Common Program activated the cutoff frequency data is loaded into all channels simultaneously upon receipt of the Load Command. In LOCAL mode, cutoff frequency data set by the CUTOFF FREQUENCY Switches is loaded into the selected channel by pressing down the momentary-contact LOAD Switch, or all channels can be loaded with the same cutoff frequency at once by selecting COMMON.

The front-panel CUTOFF FREQUENCY Indicators show the cutoff frequency operating in the channel addressed by the CHANNEL SELECT Switches, regardless of whether that cutoff frequency was loaded locally, remotely, or by the on-card switches.

NOISE LEVEL. Noise in any one filter card is at least 80 db below the full-scale signal level. When multiple filter cards are used, the signal-to-noise ratio may be somewhat degraded. Noise levels are a function of the number of filter cards being interconnected, the type of interconnection (cascade, parallel, or combination), and bandwidth. The -80 db noise floor in Figures 2-5 through 2-9 is shown for reference only.

INCREASING ROLLOFF RATE (BUTTERWORTH). Filter cards can be cascaded to increase rolloff to 96 db per octave. Figure 2-5 provides a block diagram of the filter-card interconnection and the resultant frequency-response plot. Filter cards are cascaded by connecting the output of one channel to the input of another through the rear-panel connectors. Adjacent channels should be used to minimize the length of wire. Do not connect the signal ground pins together.

For each filter card cascaded at a given fc, the output signal is down 3 db at fc. Figure 2-5 shows that with two filters, the output signal level is 6 db below the 0 db reference (input signal) level at fc.

BANDPASS FILTERING (BUTTERWORTH). Two filter cards, one in high-pass and one in low-pass, can be cascaded to provide bandpass filtering. Figure 2-6 provides the block diagram and frequency-response plot. When cascading filters for bandpass operation, the input signal should be connected to the high-pass filter, and the output of the high-pass filter is then connected to the input of the low-pass filter. Figure 2-6 shows that with one filter determining each of the two cutoff frequencies the rolloff rate is 48 db/octave.

BAND-REJECT FILTERING (BUTTERWORTH). Two filter cards, one in high-pass and one in low-pass, can be connected in parallel to provide band-reject filtering. Figure 2-7 provides the block diagram and frequency-response plot. Whenever two (or more) filters are connected in parallel, the outputs should be summed through 1K resistors. These should be 1% tolerance, non-inductive, 1/2 watt resistors. Note that this results in a 6 db insertion loss between the input and output signal levels.

DOUBLE BANDPASS FILTERING (BUTTERWORTH). Filters can be cascaded, with the cascades connected in parallel to provide two (or more) passbands. Figure 2-8 provides the block diagram and frequency-response plot for one possible combination of filters. In the example in Figure 2-8, two pairs of filters are used in the top branch to provide a 96 db/octave rolloff for the passband determined by that branch.

DOUBLE BAND-REJECT FILTERING (BUTTERWORTH). Parallel filter configurations can be cascaded to provide two (or more) stopbands. Figure 2-9 provides the block diagram and frequency-response plot for one possible combination of filters. Filters 1 and 2 comprise one band-reject filter, and the summed output is connected to the inputs of filters 3 and 4, which comprise the second band-reject filter. Note that the output reference level is 12 db below the input level.

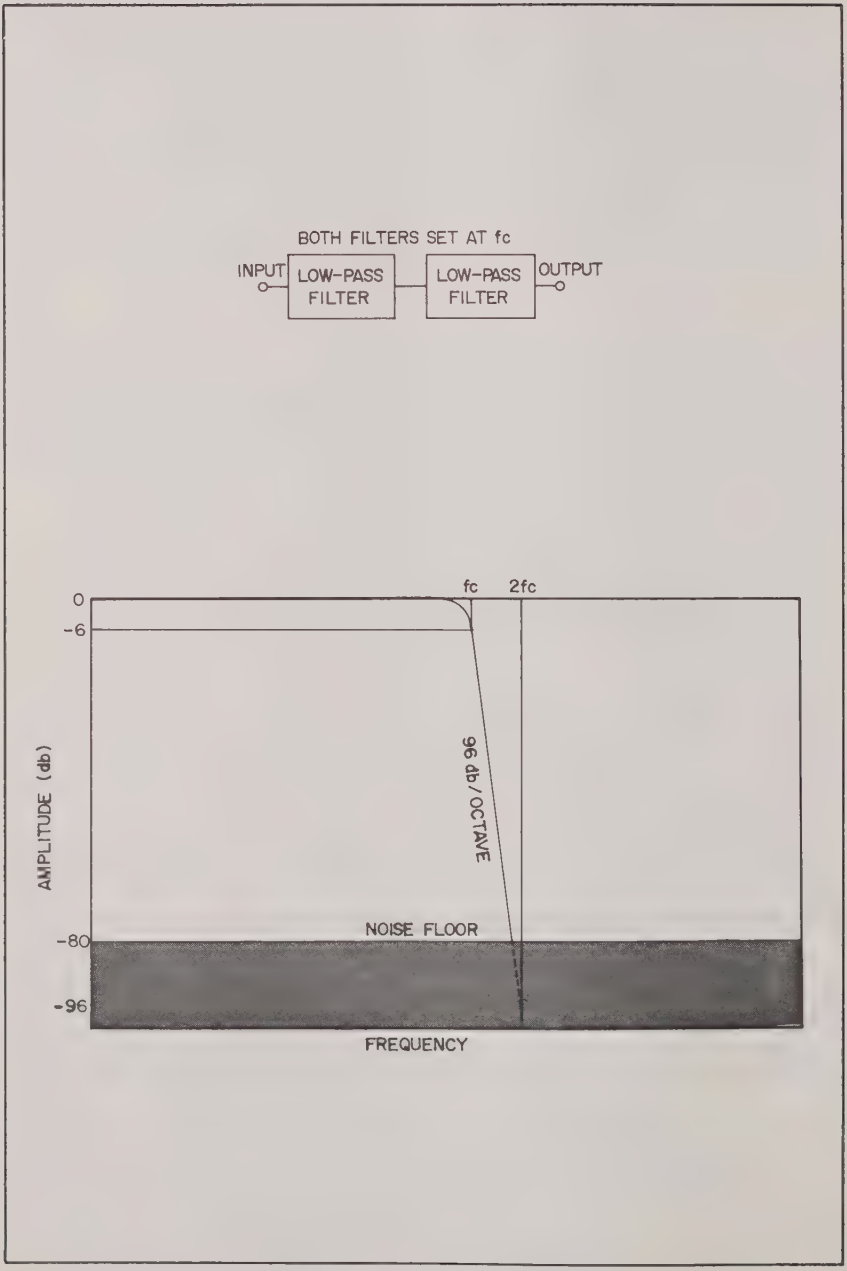



Figure 2-5. Increasing Rolloff Rate.

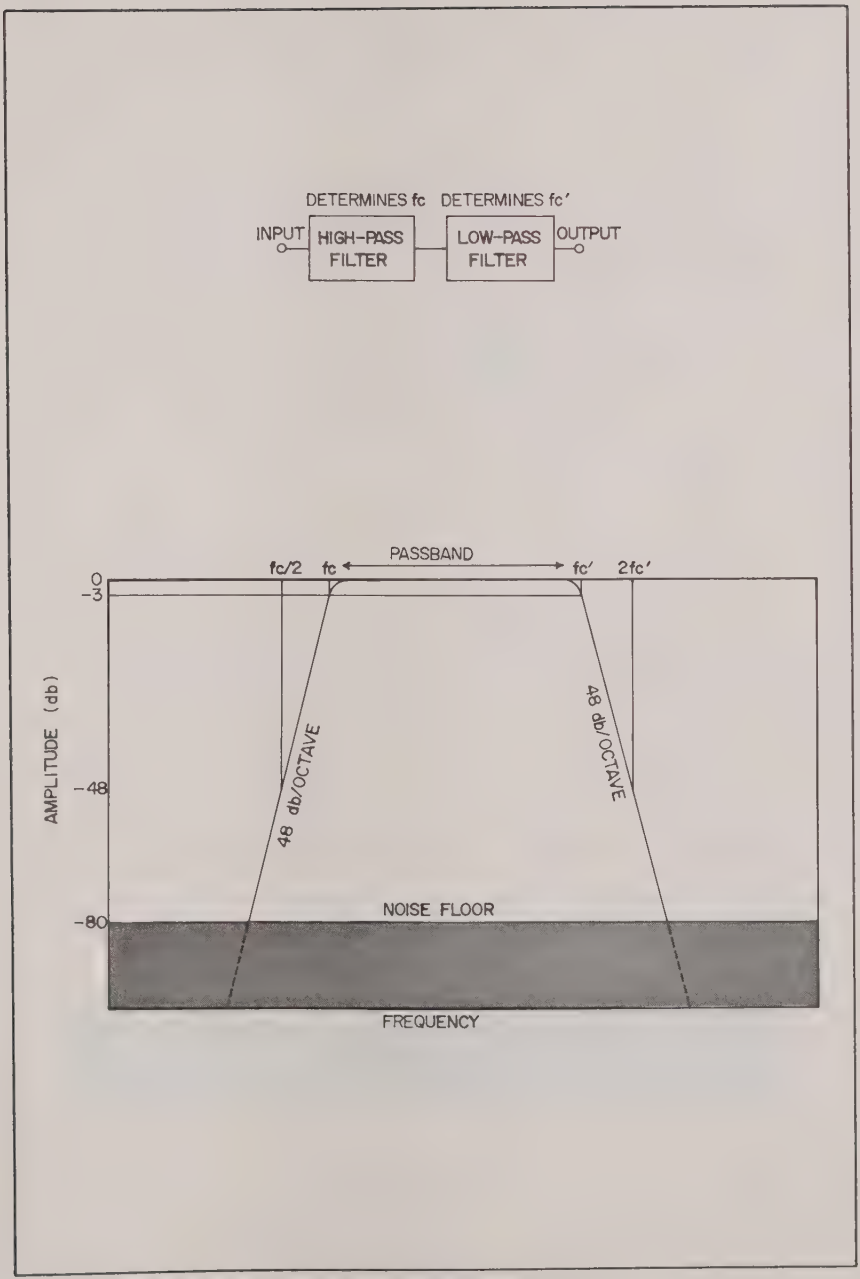



Figure 2-6. Bandpass Filtering.

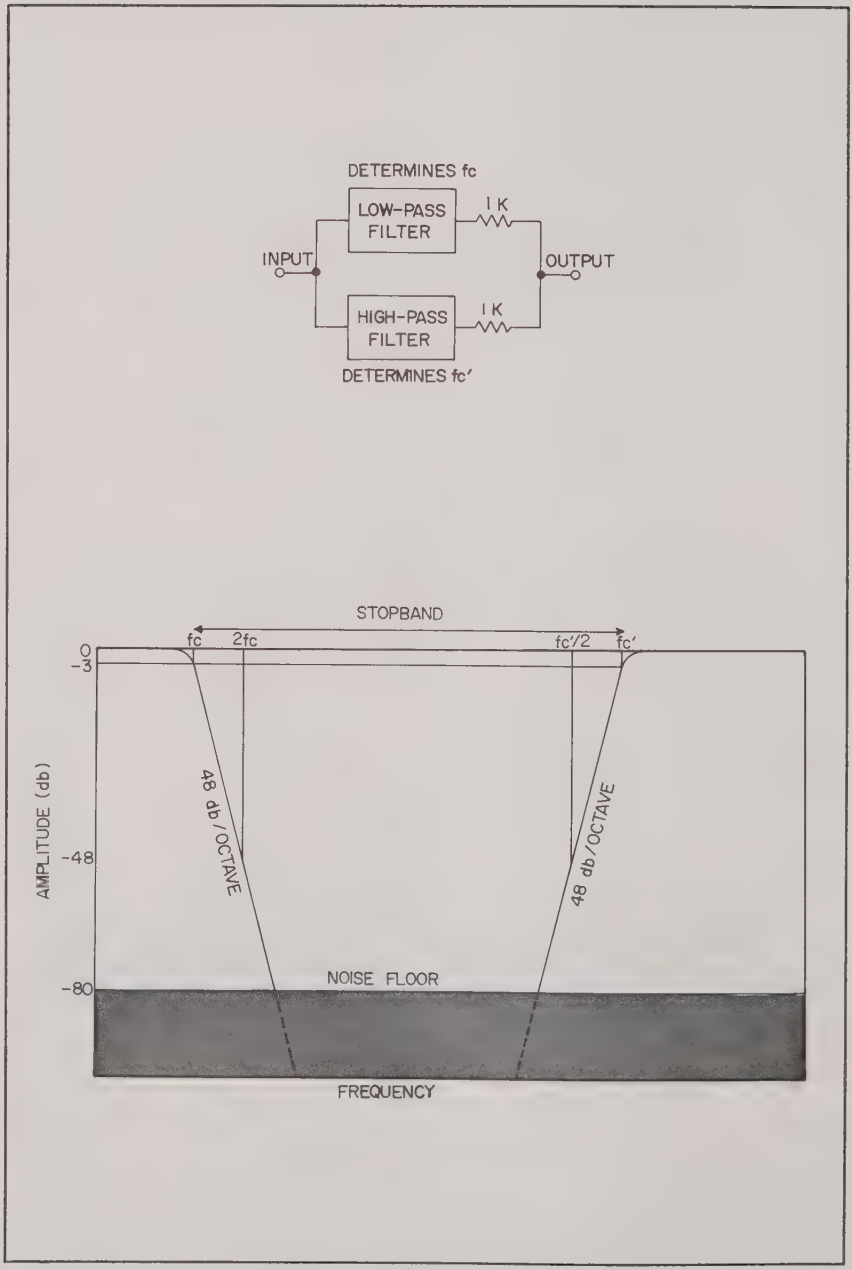
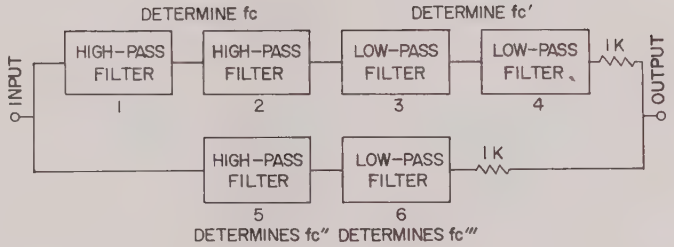



Figure 2-7. Band-Reject Filtering.



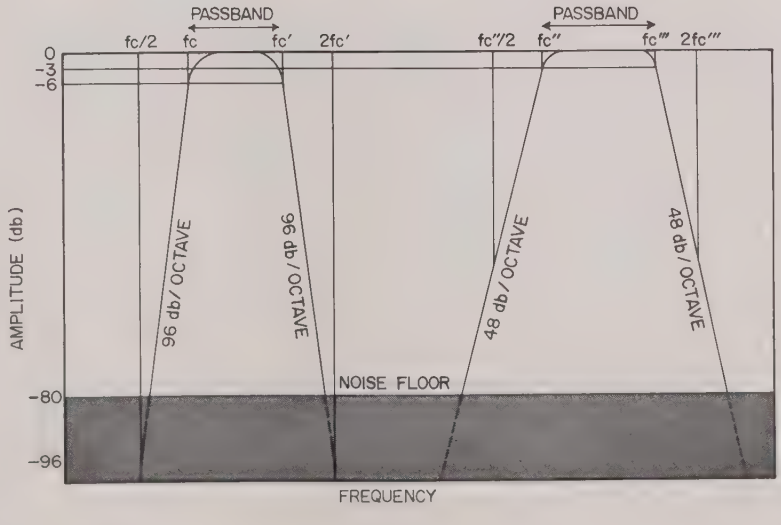
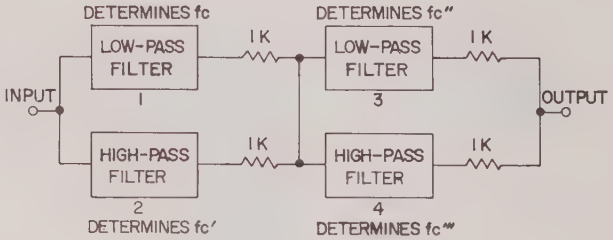




Figure 2-8. Double Bandpass Filtering.



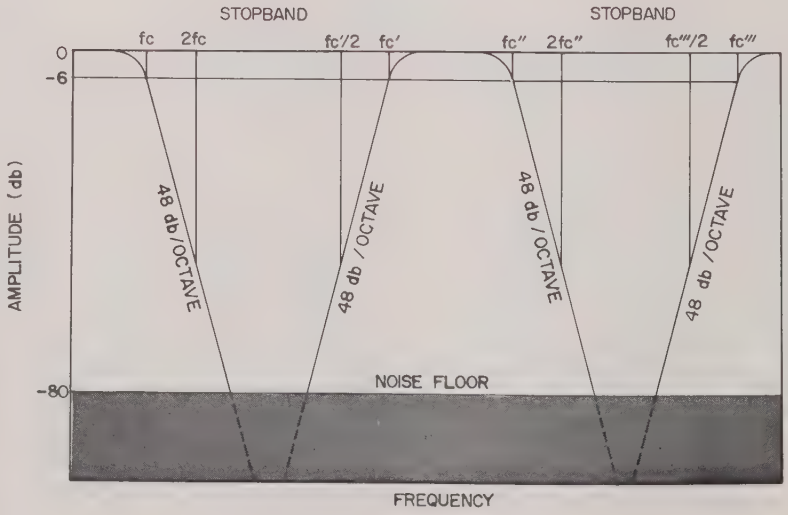
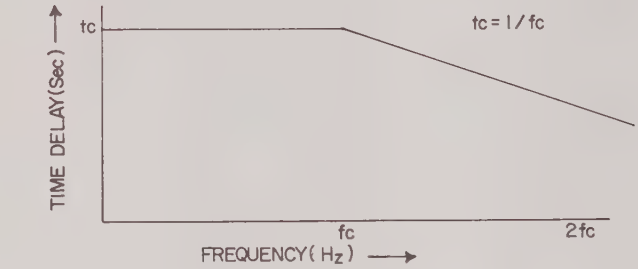




Figure 2-9. Double Band-Reject Filtering.

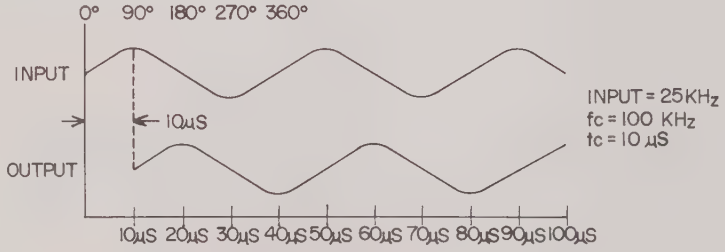
TIME DELAY (BESSEL). The phase shift of Bessel filters is linear between DC and cutoff frequency (fc). An input frequency equal to fc is shifted 360°, an input frequency equal to 1/2 fc is shifted 180°, an input frequency equal to 1/4 fc is shifted 90°, etc. This linear phase-shift characteristic allows use of Bessel filters as time-delay elements.

Figure 2-10a shows that the time delay (i.e., the derivative of phase) is constant at any fc for input frequencies up to fc. Figures 2-10b and 2-10c show the result of the 10 uS time delay obtained with a cutoff frequency of 100 KHz. The input frequency in Figure 2-10b is 25 KHz, which is 1/4 the cutoff frequency. Therefore, the output is shifted 90° from the input, which is equivalent to 1/4 period, or 10 uS. The input frequency in Figure 2-10c is 12.5 KHz, which is 1/8 the cutoff frequency. Therefore, the output is shifted 45° from the input, which is equivalent to 1/8 period, or 10 uS. Regardless of the input frequency (up to fc), the time delay is always equal to 1/fc.

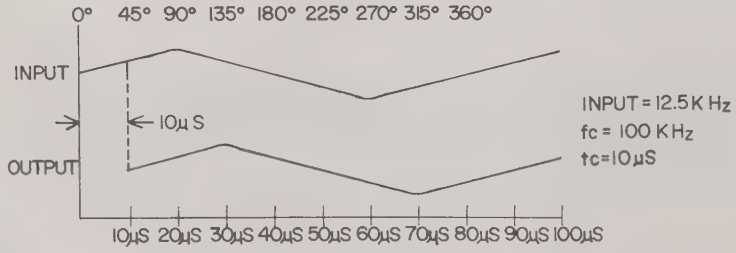
Two or more filter cards can be cascaded to lengthen the time delay. Note that output signal amplitude decreases as the input frequency approaches fc (see Figure 1-2), which may result in excessive attentuation near fc.




A. TIME DELAY VS FREQUENCY




B. 25 KHz INPUT




C. 12.5 KHz INPUT

Figure 2-10. Bessel Time Delay.

# SECTION III

# PRINCIPLES OF OPERATION

## 3-1. INTRODUCTION.

This section contains a block diagram and description of System 816, and a description of the filter card. The block diagram represents the functional operation of the instrument, and does not necessarily show actual circuit configuration. A line on the block diagram or a schematic which is labeled as a signal (e.g., LOCAL, CHANNEL SELECT 8, LOAD ACKNOWLEDGE, etc.) is high (+5 V) whenever that condition is true (operating). A negation symbol (e.g., $\overline{\text{COMMON}}$, CUTOFF FREQUENCY UNITS $\overline{1}$ $\overline{2}$ $\overline{4}$ $\overline{8}$, $\overline{\text{LOAD}}$, etc.) indicates that the signal is low (ground) whenever that condition is true (operating).

## 3-2. BLOCK DIAGRAM ANALYSIS.

Figure 3-1 is a block diagram of System 816. Switching functions shown are performed by logic circuits. Except for Filter-Card components, all blocks represent components on the Scanner Assembly. In the following paragraphs, reference designations in parentheses are the actual components represented by blocks.

Gate OR1 (U7A) determines whether the instrument responds to front-panel or remote-programming controls. If either front-panel or remote-programming REMOTE is selected, the REMOTE Indicator lights and switch sections a, b, c, and d are set at REMOTE.

Switch "a" (U24 & U27) selects whether the eight Cutoff Frequency bus lines (four Units, four Multiplier) are controlled by the front-panel CUTOFF FREQUENCY Switches or the programming lines.

Switch "b" (U11) selects the source of the channel address for the Load Command, and switch "c" (U9A) selects the source of the Load Command. There are two BCD-to-

Decimal Decoders (U15 & U16), and each one decodes the 1-2-4 BCD data into one of eight channels (0 through 7, or 8 through 15). The Load Gates (U12A, U12B, & U12D) gate the Load Command through to the proper BCD-to Decimal Decoder depending on whether or not the Channel Select "8" line is active.

System 816 also has provision for loading all channels simultaneously. Switch "d" (U9B) selects the source of this control. When selected at the front panel this signal is called Common, and when selected remotely it is called Common Program. Common Program is gated through AND 1 (U1D) only during a remote Load Command, while Common remains as long as the front-panel COMMON/LOAD Switch is at COMMON. Gate OR 2 (U20, U21, U22, & U23) gates the Load Command to one selected channel or to all 16 channels. When a Load Command is supplied to a Filter Card, the data on the eight Cutoff Frequency bus lines is loaded into the Digital Memory (U1 & U4) on that card. Gate OR 3 (U1A) selects whether the data stored on the Digital Memory or the On-Card Switches controls the cutoff frequency. If Preset is selected, either at the front panel or remotely, the PRESET Indicator lights and switch "e" (U2 & U5) is set at PRESET.

The eight inputs to the Relay Drivers are also gated out to light the front-panel CUTOFF FREQUENCY Indicators. The Read Command is supplied to the Memory Data Out Gates (U7 & U8) on only one Filter Card, as selected by the front-panel CHANNEL SELECT Switches through the BCD-to-Decimal Decoder (U13 & U14). The four inputs to this Decoder also light the CHANNEL SELECT Indicators. This enables the operator to read the cutoff frequency of any channel even though automated programming equipment may be controlling System 816.

## 3-3. FILTER CARD DESCRIPTION.

Figure 3-2 is a simplified schematic of a System 816 filter card. The 8th-order filter consists of an input circuit and four cascaded 2nd-order filter sections. Each 2nd-order section consists of an operational amplifier and feedback and coupling circuits. The

schematic is shown for a low-pass configuration, with a single section shown in high-pass configuration in Insert A. The only difference between low-pass and high-pass consists of the interchanging of the coupling capacitors and resistors.

Although the simplified schematic applies to both Butterworth and Bessel filters, the principles of operation are somewhat different and are described separately. The Butterworth description applies to Bessel filters except as noted in the Bessel description.

BUTTERWORTH FILTER CARDS. The four filter sections of the Butterworth filter are identical, except for component values of R3 and R4. The transfer function for a single section is: $\frac{Vout}{Vin} = A \frac{\omega_0^2}{s^2 + 2\beta\omega_0 s + \omega_0^2}$ where the angular frequency ($\omega_o$) = 1/RC, DC gain (A) = 1 + R3/R4, and damping factor ($\beta$) = $1 - \frac{R3}{2R4}$. It can be seen that cutoff frequency is controlled through selection of different RC coupling values, R1, C1, R2, and C2. The resistors are selected by the UNITS controls, and the capacitors are selected by the MULTIPLIER controls.

The damping factor ($\beta$) is set by the values of R3 and R4, which are selected to satisfy the mathematic requirements for synthesizing an 8th-order filter with maximally-flat amplitude response (-3 db at fc).

The DC gain (A) is also a function of the values of R3 and R4. The gain of each section is given on the simplified schematic above each section. The total gain for the four sections is approximately 6.88. The combination of the input attenuator and input amplifier provides a gain of $\frac{1}{6.88}$ so that the overall gain from input to output is unity (0 db).

BESSEL FILTER CARDS. The four filter sections of the Bessel filter are not identical, the difference being that each section has a different cutoff frequency as well as a different DC gain. The transfer function for each section is the same as for Butterworth filters: $\frac{Vout}{Vin} = A \frac{\omega_0^2}{s^2 + 2\beta\omega_0 s + \omega_0^2}$ but both angular frequency ($\omega_o$) and damping factor ($\beta$) are different for each section. These two parameters are selected to satisfy the mathematic requirements for synthesizing an 8th-order filter with maximally-flat phase shift.

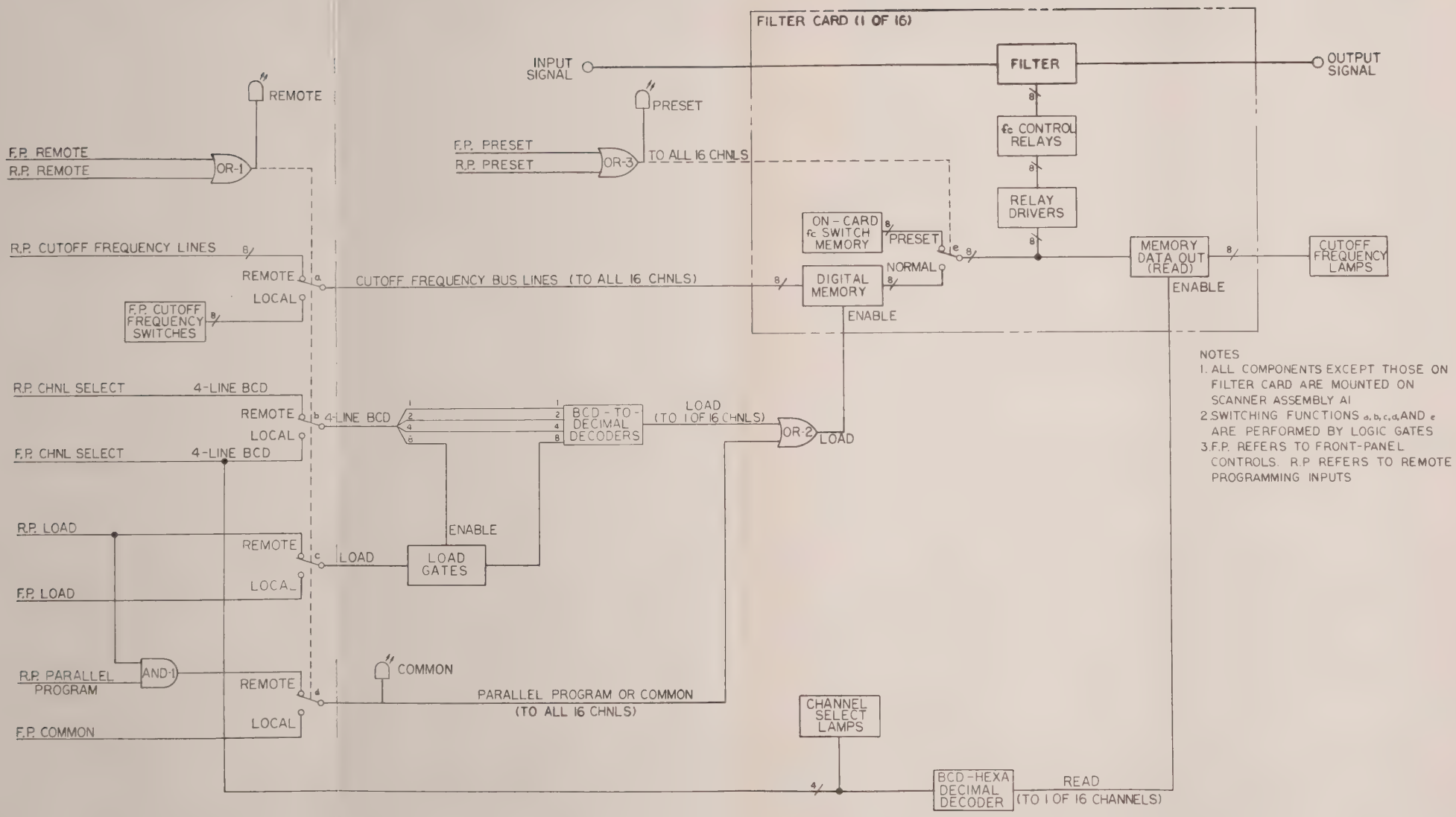



Figure 3-1. System 816 Block Diagram.

NOTES
1. THE SIMPLIFIED SCHEMATIC IS SHOWN IN LOW-PASS CONFIGURATION INSERT A SHOWS ONE STAGE IN HIGH-PASS CONFIGURATION
2. MULTIPLIER CONTROLS SELECT ONE OF FOUR POSSIBLE VALUES FOR C1 AND C2. UNITS CONTROLS CONNECT ONE, TWO, THREE, OR FOUR RESISTORS IN PARALLEL TO DETERMINE VALUES OF R1 AND R2.

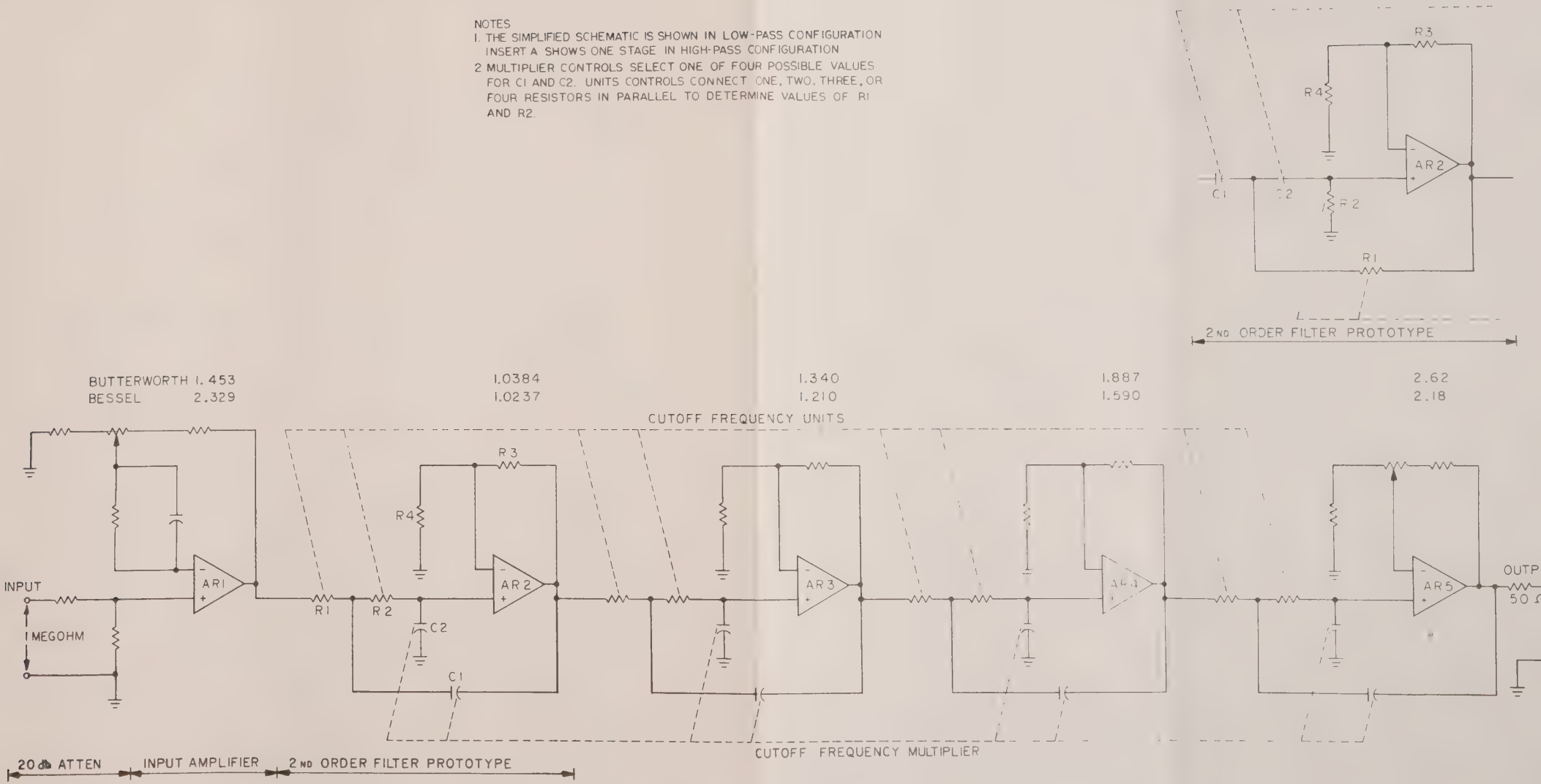



Figure 3-2. Simplified Filter Schematic.

# SECTION IV

# MAINTENANCE AND CALIBRATION

## 4-1. INTRODUCTION.

Integrated-circuit design and printed-circuit manufacturing techniques utilized in System 816 produce a highly reliable instrument which should seldom require repair or calibration. The fan motor is lubricated for the service life of the instrument. When used in a dusty environment, the interior of the instrument may require periodic cleaning with a vacuum cleaner or dry low-pressure compressed air. The exterior of the instrument can be cleaned with a mild detergent and water solution.

Corrective maintenance consists of procedures designed to correct problems that have resulted in the failure of System 816 to operate properly. Usually these procedures include troubleshooting, repair, and calibration. The test values given in the calibration section may also be used for conformance testing.

## 4-2. TROUBLESHOOTING.

The single most important aspect of troubleshooting is the formulation of a logical approach to locating the source of trouble. The technician should be familiar with the principles of operation, block diagrams, and schematics. If a malfunction is suspected, ensure that the problem is not caused by other equipment connected to System 816.

Check the fuse, power cord, and all switch settings. Confirm that all eight pairs of jumpers on each filter card are set for low-pass or high-pass operation as required. Check the settings of the on-card cutoff frequency switches, particularly the MULTIPLIER switches; only one MULTIPLIER may be on. Ensure that the proper type of filter, either Butterworth or Bessel, of the proper frequency range is being used. Bessel filter cards can be identified by the hard-wired jumpers in place of the plug-in jumpers used on Butterworth filter

cards. The frequency range of a filter card is given by the label next to the on-card MULTIPLIER switches.

If System 816 is found to be malfunctioning, check to ensure that plug-in assemblies are correctly aligned and fully seated. Look for loose or broken wiring, bent connector pins, leaking capacitors, cracked printed-circuit boards, and discolored components.

System 816 can be separated into digital control circuits and analog signal circuits. A problem can be isolated to one of these two areas by use of the front-panel controls and indicators. (It may be helpful to refer to the System 816 block diagram.) Set a cutoff frequency value and load it into the channel to be checked. If the front-panel LED readout indicates the correct cutoff frequency, all control logic circuits are functioning properly, and the problem must be located in the relay drivers, relays, or filter circuits. If the front-panel readout does not indicate the cutoff frequency that was loaded, the problem must be located in the logic circuits.

ANALOG SIGNAL CIRCUITS. If the problem is isolated to the analog circuits it can be further isolated with the front-panel controls. (Refer to the simplified schematic of the filter card.) The cutoff frequency is controlled by varying the RC coupling between filter stages. The UNITS controls select the resistors, and the MULTIPLIER controls select the capacitors. Select any one MULTIPLIER range and set the UNITS controls for "1". Monitor the output signal to determine the correct attenuation at cutoff frequency (3 db for Butterworth, 13.6 db for Bessel). Repeat the procedure for UNITS values of "2", "4", and "8". If the cutoff frequency is correct in all cases, the coupling resistors and the relays which select them are all functioning properly. Next, select a UNITS value and check the cutoff frequency for all four MULTIPLIER ranges. This step tests the coupling capacitors and the relays which select them. If the problem cannot be isolated by these steps, it must be in the input circuit or operational amplifiers. The gain values for each amplifier stage given on the simplified filter schematic can be used to further isolate the problem.

DIGITAL CONTROL CIRCUITS. Lines on the scanner and filter card schematics which are labeled as signals (e.g., REMOTE, LOAD, 8, etc.) are high (+5V) whenever that condition is true (operating). Signal lines whose labels include a negation symbol (e.g., $\overline{\text{COMMON}}$, $\overline{\text{REMOTE}}$, $\overline{8}$, $\overline{4}$, $\overline{2}$, $\overline{1}$, etc.) are low (ground) whenever that condition is true (operating). A check for the proper logic levels will typically isolate the problem to a particular component. If a problem appears to exist in more than one area, look for a component common to the problem areas.

## 4-3. REPAIR.

Repair of System 816 is accomplished using standard printed-circuit repair techniques. Circuit connections are made on both sides of the printed-circuit boards. Therefore, after a component is removed, check for continuity between the circuits on each side of the printed-circuit board. A small "Z" wire may be required if continuity is lost through the hole, and the component to be replaced obscures the lead on the top side of the board.

WARNING

Disconnect the Power cord from the instrument
before removing the scanner assembly.

To remove the front-panel scanner assembly, remove the top cover. Remove the two screws which secure the rail over the scanner assembly and remove the rail. Unplug the two power lines which connect to the back of the scanner assembly on the right-hand side (as viewed from the front). Grasp the front panel firmly, and pull the assembly straight up and out of the mainframe. When replacing the scanner assembly be certain to align the printed-circuit contacts with the sockets on the motherboard, and push the assembly firmly and straight into place. Reconnect the two power lines to the assembly.

## 4-4. CALIBRATION.

System 816 contains three user-servicable adjustments. Ordinarily these will require adjustment only if certain components are replaced. The following paragraphs describe the checking and setting of each adjustment. Potentiometers R4 and R41 on the filter card require readjustment only if R3, R5, R40, or R42 are replaced. Capacitor C20 on the filter card requires readjustment only if C21 is replaced. These are factory-only adjustments, and should not be attempted by the user.

POWER SUPPLY ADJUSTMENT. Turn the POWER switch on and check the voltage on the +24 volt bus (pin 2 of XA2B-XA17B). Adjust R1 on the motherboard for a reading of +24 volts (+1, -0).

DC OFFSET ADJUSTMENTS. Potentiometers R7 and R43 (Butterworth only) on the filter cards may require readjustment if the operational amplifiers AR1 or AR5 are replaced.

For Butterworth cards, turn the POWER Switch off and connect the four pairs of jumpers on the left side of the filter card for high-pass operation. Turn the POWER Switch on, and set the front-panel controls to COMMON, NORMAL, and LOCAL. Set a UNITS value of "2" and the highest MULTIPLIER range. Connect an oscilloscope probe to the output pin at the rear-panel connector, and set the oscilloscope controls for DC coupling and vertical sensitivity of 0.01 volts/division. Adjust R43 for zero DC offset. Turn the POWER Switch off, and reconnect all jumpers for low-pass operation. Turn POWER Switch on and adjust R7 for zero DC offset.

For Bessel cards, turn the POWER Switch on, and set the front-panel controls to COMMON, NORMAL, and LOCAL. Set a UNITS value of "2" and the highest MULTIPLIER range. Monitor the output and adjust R7 for zero DC offset.

# SECTION V

# PARTS LIST

## 5-1. INTRODUCTION

This section contains an alphanumeric listing of all replaceable electrical parts used in the instrument. Reference designations and abbreviations applying to the parts list are provided below. Multiple entries for one reference designation indicate that one of two or more component values may be used.

## 5-2. ORDERING INFORMATION

To order a replacement part, address inquiry to your Wavetek Representative, or:

Wavetek San Diego, Inc.
9045 Balboa Ave.
San Diego, CA 92123
Phone: (619) 279-2200
TWX: (910) 355-2007

Specify the following information:

1) Model and serial number of instrument

2) Circuit reference designation

3) Wavetek/Rockland part number

4) Description of part

REFERENCE DESIGNATIONS

| | | | |
|---|---|---|---|
| A | Assembly | MP | Mechanical Part |
| AR | Amplifier | P | Plug |
| B | Motor | Q | Transistor |
| C | Capacitor | R | Resistor |
| CR | Diode | S | Switch |
| DS | Device Indicator | T | Transformer |
| F | Fuse | U | Microcircuit |
| FL | Filter | VR | Voltage Regulator |
| J | Connector | X | Socket |
| K | Relay | | |

## ABBREVIATIONS

| | |
|---|---|
| AMPL | Amplifier |
| AOI | AND-OR-INVERT Gate |
| ASSY | Assembly |
| CAP | Capacitor |
| Cer | Ceramic |
| Comp | Composition |
| CONN | Connector |
| DIO | Diode |
| DR | Double row |
| Elect | Electrolytic |
| FWB | Four-way Bridge |
| FXD | Fixed |
| GaAsP | Galium Arsenide Phosphide |
| IC | Integrated Circuit |
| LED | Light-emitting Diode |
| MLPX | Multiplexer |
| Metflm | Metal Film |
| Mom | Momentary |
| NET | Network |
| O/C | Open Collector |
| PC | Printed Circuit |
| PIV | Peak Inverse Voltage |
| Pos | Position |
| REG | Regulator |
| RES | Resistor |
| REL | Relay |
| Sel | Selector |
| Sil | Silicon |
| SR | Single row |
| SW | Switch |
| Tant | Tantalum |
| TSTR | Transistor |
| Var | Variable |
| WW | Wirewound |
| XMFR | Transformer |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | MOTHERBOARD (p.n. 004-0820) And CHASSIS ASSEMBLY | |
| B1 | FAN: 3-1/8", 115 V, 50/100 Hz | 165-0703 |
| C1 | CAP: Fxd elect 3000uF 50 V | 109-8300 |
| C2 | CAP: Fxd elect 3000uF 50 V | 109-8300 |
| C3 | CAP: Fxd tant 0.1uF 20% 35V | 109-4100 |
| C4 | CAP: Fxd tant 0.1uF 20% 35V | 109-4100 |
| C5 | CAP: Fxd elect 3000uF 50V | 109-8300 |
| C6 | CAP: Fxd cer 0.01uF +80 -20% 10 V | 100-3100 |
| C7 | CAP: Fxd tant 10uF 20% 35 V | 109-6100 |
| C8 | CAP: Fxd cer 0.1uF +80 -20% 15 V | 100-4100 |
| C9 | CAP: Fxd elect 10,000uF 15 V | 109-9100 |
| C10 | CAP: Fxd elect 10,000uF 15 V | 109-9100 |
| C11 | CAP: Fxd elect 10,000uF 15 V | 109-9100 |
| C12 | CAP: Fxd cer 0.1uF +80 -20% 15 V | 100-4100 |
| C13 | CAP: Fxd cer 0.1uF +80 -20% 15 V | 100-4100 |
| C14 | CAP: Fxd cer 0.1uF +80 -20% 15 V | 100-4100 |
| C15 | CAP: Fxd tant 0.1uF 20% 35 V | 109-4100 |
| C16 | CAP: Fxd paper 0.47uF 10% 600 V | 103-4470 |
| CR1 | DIO: Sil FWB 50 PIV 1.5A | 130-0140 |
| CR2 | DIO: Sil FWB 50 PIV 5A | 130-0440 |
| CR3 | DIO: Sil FWB 50 PIV 12A | 130-0541 |
| F1 | FUSE: 3AG 2A 5B | 165-4004 |
| FL1 | FILTER: Power line 3A | 165-3001 |
| MP1 | HEAT SINK: TO-3 | 367-0403 |
| MP2 | HEAT SINK: TO-3 | 367-0403 |
| Q1 | TSTR: Sil PNP 2N4354 | 136-4354 |
| R1 | RES: Var WW 1.5K 10% 1/2W | 118-2154 |
| R2 | RES: Fxd comp 2.2K 5% 1/4W | 116-2221 |
| R3 | RES: Fxd comp 560 ohm 5% 1/2W | 116-1562 |
| R4 | RES: Fxd comp 1.5K 5% 1/2W | 116-2152 |
| R5 | RES: Fxd comp 1.5K 5% 1/2W | 116-2152 |
| S1 | SW: Slide DPDT (115/230) | 342-2201 |
| T1 | XMFR: Power | 177-3007 |
| VR1 | REG: Positive volt, 5 V 5% 1A | 120-0051 |
| VR2 | REG: Positive volt, 5 V 5% 1A | 120-0051 |
| VR3 | REG: Positive volt, 5 V 5% 1A | 120-0051 |
| XA1A | CONN: PC .156 22 pos DR short dip tail | 350-4401 |
| XA1B | CONN: PC .156 22 pos DR short dip tail | 350-4401 |
| XA2A | CONN: PC .156 22 pos SR short dip tail | 350-2202 |
| XA2B | CONN: PC .156 10 pos SR short dip tail | 350-1002 |
| XA3A | CONN: PC .156 22 pos SR short dip tail | 350-2202 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | MOTHERBOARD (p.n. 004-0820) And CHASSIS ASSEMBLY (cont) | |
| XA3B | CONN: PC .156 10 pos SR short dip tail | 350-1002 |
| XA4A | CONN: PC .156 22 pos SR short dip tail | 350-2202 |
| XA4B | CONN: PC .156 10 pos SR short dip tail | 350-1002 |
| XA5A | CONN: PC .156 22 pos SR short dip tail | 350-2202 |
| XA5B | CONN: PC .156 10 pos SR short dip tail | 350-1002 |
| XA6A | CONN: PC .156 22 pos SR short dip tail | 350-2202 |
| XA6B | CONN: PC .156 10 pos SR short dip tail | 350-1002 |
| XA7A | CONN: PC .156 22 pos SR short dip tail | 350-2202 |
| XA7B | CONN: PC .156 10 pos SR short dip tail | 350-1002 |
| XA8A | CONN: PC .156 22 pos SR short dip tail | 350-2202 |
| XA8B | CONN: PC .156 10 pos SR short dip tail | 350-1002 |
| XA9A | CONN: PC .156 22 pos SR short dip tail | 350-2202 |
| XA9B | CONN: PC .156 10 pos SR short dip tail | 350-1002 |
| XA10A | CONN: PC .156 22 pos SR short dip tail | 350-2202 |
| XA10B | CONN: PC .156 10 pos SR short dip tail | 350-1002 |
| XA11A | CONN: PC .156 22 pos SR short dip tail | 350-2202 |
| XA11B | CONN: PC .156 10 pos SR short dip tail | 350-1002 |
| XA12A | CONN: PC .156 22 pos SR short dip tail | 350-2202 |
| XA12B | CONN: PC .156 10 pos SR short dip tail | 350-1002 |
| XA13A | CONN: PC .156 22 pos SR short dip tail | 350-2202 |
| XA13B | CONN: PC .156 10 pos SR short dip tail | 350-1002 |
| XA14A | CONN: PC .156 22 pos SR short dip tail | 350-2202 |
| XA14B | CONN: PC .156 10 pos SR short dip tail | 350-1002 |
| XA15A | CONN: PC .156 22 pos SR short dip tail | 350-2202 |
| XA15B | CONN: PC .156 10 pos SR short dip tail | 350-1002 |
| XA16A | CONN: PC .156 22 pos SR short dip tail | 350-2202 |
| XA16B | CONN: PC .156 10 pos SR short dip tail | 350-1002 |
| XA17A | CONN: PC .156 22 pos SR short dip tail | 350-2202 |
| XA17B | CONN: PC .156 10 pos SR short dip tail | 350-1002 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | SCANNER ASSEMBLY p.n. 004-0810 | |
| C1 | CAP: Tant 10.0uF | 109-6100 |
| C2 | CAP: Fxd mica dipped 500pF 10% 500 V | 101-1500 |
| C3 | CAP: Fxd tant 68uF 20% 6 V | 109-6680 |
| C4 | CAP: Fxd cer 0.10uF +80 -20% 15 V | 100-4100 |
| C5 | CAP: Fxd cer 0.10uF +80 -20% 15 V | 100-4100 |
| CR1 | DIO: Low leak 70 PIV 200 mW | 132-0457 |
| CR2 | DIO: Low leak 70 PIV 200 mW | 132-0457 |
| DS1 | LED: Red GaAsP | 171-1600 |
| DS2 | LED: Red GaAsP | 171-1600 |
| DS3 | LED: Red GaAsP | 171-1600 |
| DS4 | LED: Red GaAsP | 171-1600 |
| DS5 | LED: Red GaAsP | 171-1600 |
| DS6 | LED: Red GaAsP | 171-1600 |
| DS7 | LED: Red GaAsP | 171-1600 |
| DS8 | LED: Red GaAsP | 171-1600 |
| DS9 | LED: Red GaAsP | 171-1600 |
| DS10 | LED: Red GaAsP | 171-1600 |
| DS11 | LED: Red GaAsP | 171-1600 |
| DS12 | LED: Red GaAsP | 171-1600 |
| DS13 | LED: Red GaAsP | 171-1600 |
| DS14 | LED: Red GaAsP | 171-1600 |
| DS15 | LED: Red GaAsP | 171-1600 |
| DS16 | LED: Red GaAsP | 171-1600 |
| R1 | NET: Res (13) 3.3K 2% | 128-2330 |
| R2 | NET: Res (13) 3.3K 2% | 128-2330 |
| R3 | NET: Res (15) 150 ohm 2% | 128-1151 |
| R4 | NET: Res (13) 3.3K 2% | 128-2330 |
| R5 | NET: Res (13) 3.3K 2% | 128-2330 |
| S1 | SW: Toggle SPDT on-on | 340-1202 |
| S2 | SW: Toggle SPDT on-on | 340-1202 |
| S3 | SW: Toggle SPDT on-on | 340-1202 |
| S4 | SW: Toggle SPDT on-on | 340-1202 |
| S5 | SW: Toggle SPDT on-on | 340-1202 |
| S6 | SW: Toggle SPDT on-on | 340-1202 |
| S7 | SW: Toggle SPDT on-on | 340-1202 |
| S8 | SW: Toggle SPDT on-on | 340-1202 |
| S9 | SW: Toggle SPDT on-on | 340-1202 |
| S10 | SW: Toggle SPDT on-on | 340-1202 |
| S11 | SW: Toggle SPDT on-on | 340-1202 |
| S12 | SW: Toggle SPDT on-on | 340-1202 |
| S13 | SW: Toggle SPDT on-off-mom on | 340-1203 |
| S14 | SW: Toggle SPDT on-on | 340-1202 |
| S15 | SW: Toggle SPDT on-on | 340-1202 |
| S16 | SW: Toggle SPDT on-on | 340-1202 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | SCANNER ASSEMBLY p.n. 004-0810 (cont) | |
| U1 | IC: Quad 2-input NAND Buffer | 122-7437 |
| U2 | IC: Quad 2-input NAND Buffer, O/C | 122-7438 |
| U3 | IC: Dual peripheral driver | 120-4451 |
| U4 | IC: Dual peripheral driver | 120-4451 |
| U5 | IC: Dual peripheral driver | 120-4451 |
| U6 | IC: Dual peripheral driver | 120-4451 |
| U7 | IC: Quad 2-input NAND | 122-7400 |
| U8 | IC: Hex inverter | 122-7404 |
| U9 | IC: Dual 2-input 2-wide AOI | 122-7451 |
| U10 | IC: Hex inverter | 122-7404 |
| U11 | IC: Quad 2-input Data Sel/MLPX | 122-0112 |
| U12 | IC: Quad 2-input NAND | 122-7400 |
| U13 | IC: BCD-to-decimal decoder | 122-7442 |
| U14 | IC: BCD-to-decimal decoder | 122-7442 |
| U15 | IC: BCD-to-decimal decoder | 122-7442 |
| U16 | IC: BCD-to-decimal decoder | 122-7442 |
| U17 | IC: Hex inverter | 122-7404 |
| U18 | IC: Hex inverter | 122-7404 |
| U19 | IC: Hex inverter | 122-7404 |
| U20 | IC: Quad 2-input NAND Buffer | 122-7437 |
| U21 | IC: Quad 2-input NAND Buffer | 122-7437 |
| U22 | IC: Quad 2-input NAND Buffer | 122-7437 |
| U23 | IC: Quad 2-input NAND Buffer | 122-7437 |
| U24 | IC: Quad 2-input Data Sel/MLPX | 122-0112 |
| U25 | IC: Hex inverter | 122-7404 |
| U26 | IC: Quad 2-input NAND Buffer | 122-7437 |
| U27 | IC: Quad 2-input Data Sel/MLPX | 122-0112 |
| U28 | IC: Quad 2-input NAND Buffer | 122-7437 |
| U29 | IC: Dual 4-input NAND Buffer | 122-7440 |
| VR1 | REG: Positive volt 5 V 5% 1A | 120-0051 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BUTTERWORTH 10 Hz-150 KHz FILTER ASSEMBLY (01) p.n. 004-0830 | |
| AR1 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR2 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR3 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR4 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR5 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| C1 | CAP: Fxd tant 0.1uF 20% 35 V | 109-4100 |
| C2 | CAP: Fxd tant 0.1uF 20% 35 V | 109-4100 |
| C3 | CAP: Fxd polyester 0.0015uF 10% 100 V | 105-2150 |
| C4 | CAP: Fxd polyester 0.0015uF 10% 100 V | 105-2150 |
| C5 | CAP: Fxd elect 50uF 25 V | 109-6500 |
| C6 | CAP: Fxd cer 0.1uF +80 -20% 15 V | 100-4100 |
| C7 | CAP: Fxd tant 1uF 20% 35 V | 109-5100 |
| C8 | CAP: Fxd tant 1uF 20% 35 V | 109-5100 |
| C9 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C10 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C11 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C12 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C13 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C14 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C15 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C16 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C17 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C18 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C19 | CAP: Fxd mica dipped 100pF 10% 500 V | 101-1100 |
| C20 | CAP: Var mica 2-25pF 175 V | 108-0250 |
| C21 | CAP: Fxd mica dipped 100pF 10% 500 V | 101-1100 |
| C22 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C23 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C24 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C25 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C26 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C27 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C28 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C29 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C30 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C31 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C32 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C33 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C34 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C35 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C36 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C37 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C38 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C39 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C40 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C41 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C42 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C43 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BUTTERWORTH 10 Hz-150 KHz FILTER ASSEMBLY (01) p.n. 004-0830 (cont) | |
| C44 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C45 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C46 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C47 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C48 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C49 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C50 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C51 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C52 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C53 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C54 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C55 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C56 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C57 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C58 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C59 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C60 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C61 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| CR1 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR2 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR3 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR4 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR5 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR6 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR7 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR8 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR9 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR10 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR11 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR12 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR13 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR14 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR15 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR16 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| K1 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K2 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K3 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K4 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K5 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K6 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K7 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K8 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K9 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K10 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K11 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K12 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K13 | REL: Reed 4PST 24 V 180 mA | 175-1503 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BUTTERWORTH 10 Hz-150 KHz FILTER ASSEMBLY (01) p.n. 004-0830 (cont) | |
| K14 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K15 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K16 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| R1 | RES: Fxd comp 4.7 ohm 5% 1/4W | 116-9471 |
| R2 | RES: Fxd comp 4.7 ohm 5% 1/4W | 116-9471 |
| R3 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R4 | RES: Var cermet 50 ohm 10% | 118-0500 |
| R5 | RES: Fxd metflm 453 ohm 1% 1/8W | 110-4530 |
| R6 | RES: Fxd metflm 100K 1% 1/8W | 113-1000 |
| R7 | RES: Var cermet 20K 10% 3/4W | 118-3200 |
| R8 | RES: Fxd metflm 909K 1% 1/8W | 113-9090 |
| R9 | RES: Fxd metflm 100K 1% 1/8W | 113-1000 |
| R10 | RES: Fxd metflm 1.50K 1% 1/8W | 111-1500 |
| R11 | RES: Fxd metflm 57.6 ohm 1% 1/8W | 119-5760 |
| R12 | RES: Fxd metflm 15.9K 1% 1/8W | 112-1590 |
| R13 | RES: Fxd metflm 7.96K 1% 1/8W | 111-7960 |
| R14 | RES: Fxd metflm 3.98K 1% 1/8W | 111-3980 |
| R15 | RES: Fxd metflm 1.99K 1% 1/8W | 111-1990 |
| R16 | RES: Fxd metflm 15.9K 1% 1/8W | 112-1590 |
| R17 | RES: Fxd metflm 7.96K 1% 1/8W | 111-7960 |
| R18 | RES: Fxd metflm 3.98K 1% 1/8W | 111-3980 |
| R19 | RES: Fxd metflm 1.99K 1% 1/8W | 111-1990 |
| R20 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R21 | RES: Fxd metflm 340 ohm 1% 1/8W | 110-3400 |
| R22 | RES: Fxd metflm 15.9K 1% 1/8W | 112-1590 |
| R23 | RES: Fxd metflm 7.96K 1% 1/8W | 111-7960 |
| R24 | RES: Fxd metflm 3.98K 1% 1/8W | 111-3980 |
| R25 | RES: Fxd metflm 1.99K 1% 1/8W | 111-1990 |
| R26 | RES: Fxd metflm 15.9K 1% 1/8W | 112-1590 |
| R27 | RES: Fxd metflm 7.96K 1% 1/8W | 111-7960 |
| R28 | RES: Fxd metflm 3.98K 1% 1/8W | 111-3980 |
| R29 | RES: Fxd metflm 1.99K 1% 1/8W | 111-1990 |
| R30 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R31 | RES: Fxd metflm 887 ohm 1% 1/8W | 110-8870 |
| R32 | RES: Fxd metflm 15.9K 1% 1/8W | 112-1590 |
| R33 | RES: Fxd metflm 7.96K 1% 1/8W | 111-7960 |
| R34 | RES: Fxd metflm 3.98K 1% 1/8W | 111-3980 |
| R35 | RES: Fxd metflm 1.99K 1% 1/8W | 111-1990 |
| R36 | RES: Fxd metflm 15.9K 1% 1/8W | 112-1590 |
| R37 | RES: Fxd metflm 7.96K 1% 1/8W | 111-7960 |
| R38 | RES: Fxd metflm 3.98K 1% 1/8W | 111-3980 |
| R39 | RES: Fxd metflm 1.99K 1% 1/8W | 111-1990 |
| R40 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R41 | RES: Var cermet 20 ohm 10% | 118-0200 |
| R42 | RES: Fxd metflm 1.62K 1% 1/8W | 111-1620 |
| R43 | RES: Var cermet 20K 10% 3/4W | 118-3200 |
| R44 | RES: Fxd metflm 15.9K 1% 1/8W | 112-1590 |
| R45 | RES: Fxd metflm 7.96K 1% 1/8W | 111-7960 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BUTTERWORTH 10 Hz-150 KHz FILTER ASSEMBLY (01) p.n. 004-0830 (cont) | |
| R46 | RES: Fxd metflm 3.98K 1% 1/8W | 111-3980 |
| R47 | RES: Fxd metflm 1.99K 1% 1/8W | 111-1990 |
| R48 | RES: Fxd metflm 15.9K 1% 1/8W | 112-1590 |
| R49 | RES: Fxd metflm 7.96K 1% 1/8W | 111-7960 |
| R50 | RES: Fxd metflm 3.98K 1% 1/8W | 111-3980 |
| R51 | RES: Fxd metflm 1.99K 1% 1/8W | 111-1990 |
| R52 | RES: Fxd comp 47 ohm 5% 1/4W | 116-0471 |
| S1 | SW: Slide SPST X4 | 342-4100 |
| S2 | SW: Slide SPST X4 | 342-4100 |
| U1 | IC: Quad Bistable latch | 122-7475 |
| U2 | IC: Quad 2-input Data Sel/MLPX | 122-0112 |
| U3 | IC: Hex inverter buffer/driver O/C | 122-7406 |
| U4 | IC: Quad Bistable latch | 122-7475 |
| U5 | IC: Quad 2-input Data Sel/MLPX | 122-0112 |
| U6 | IC: Hex inverter buffer/driver O/C | 122-7406 |
| U7 | IC: Quad 2-input NAND O/C | 122-7401 |
| U8 | IC: Quad 2-input NAND O/C | 122-7401 |
| VR1 | REG: Dual $\pm$ 15 volt 100 mA | 120-0152 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BUTTERWORTH 1 Hz-15 KHz FILTER ASSEMBLY (02) p.n. 004-0840 | |
| AR1 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR2 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR3 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR4 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR5 | IC AMPL: Linear Op Amp 8007 | 120-1009 |
| C1 | CAP: Fxd tant 0.1uF 20% 35 V | 109-4100 |
| C2 | CAP: Fxd tant 0.1uF 20% 35 V | 109-4100 |
| C3 | CAP: Fxd polyester 0.0015uF 10% 100 V | 105-2150 |
| C4 | CAP: Fxd polyester 0.0015uF 10% 100 V | 105-2150 |
| C5 | CAP: Fxd elect 50uF 25 V | 109-6500 |
| C6 | CAP: Fxd cer 0.1uF +80 -20% 15 V | 100-4100 |
| C7 | CAP: Fxd tant 1uF 20% 35 V | 109-5100 |
| C8 | CAP: Fxd tant 1uF 20% 35 V | 109-5100 |
| C9 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C10 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C11 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C12 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C13 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C14 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C15 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C16 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C17 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C18 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C19 | CAP: Fxd mica dipped 100pF 10% 500 V | 101-1100 |
| C20 | CAP: Var mica 2-25pF 175 V | 108-0250 |
| C21 | CAP: Fxd mica dipped 100pF 10% 500 V | 101-1100 |
| C22 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C23 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C24 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C25 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C26 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C27 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C28 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C29 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C30 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C31 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C32 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C33 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C34 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C35 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C36 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C37 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C38 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C39 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C40 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C41 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C42 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C43 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C44 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BUTTERWORTH 1 Hz-15 KHz FILTER ASSEMBLY (02) p.n. 004-0840 (cont) | |
| C45 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C46 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C47 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C48 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C49 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C50 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C51 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C52 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C53 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C54 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C55 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C56 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C57 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C58 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C59 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C60 | CAP: Fxd mica dipped 10 pF 10% 500 V | 101-0100 |
| C61 | CAP: Fxd mica dipped 10 pF 10% 500 V | 101-0100 |
| CR1 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR2 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR3 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR4 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR5 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR6 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR7 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR8 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR9 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR10 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR11 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR12 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR13 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR14 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR15 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR16 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| K1 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K2 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K3 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K4 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K5 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K6 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K7 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K8 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K9 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K10 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K11 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K12 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K13 | REL: Reed 4PST 24 V 180 mA | 175-1503 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BUTTERWORTH 1 Hz-15 KHz FILTER ASSEMBLY (02) p.n. 004-0840 (cont) | |
| K14 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K15 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K16 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| R1 | RES: Fxd comp 4.7 ohm 5% 1/4W | 116-9471 |
| R2 | RES: Fxd comp 4.7 ohm 5% 1/4W | 116-9471 |
| R3 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R4 | RES: Var cermet 50 ohm 10% | 118-0500 |
| R5 | RES: Fxd metflm 453 ohm 1% 1/8W | 110-4530 |
| R6 | RES: Fxd metflm 100K 1% 1/8W | 113-1000 |
| R7 | RES: Var cermet 20K 10% 3/4W | 118-3200 |
| R8 | RES: Fxd metflm 909K 1% 1/8W | 113-9090 |
| R9 | RES: Fxd metflm 100K 1% 1/8W | 113-1000 |
| R10 | RES: Fxd metflm 1.50K 1% 1/8W | 111-1500 |
| R11 | RES: Fxd metflm 57.6 ohm 1% 1/8W | 119-5760 |
| R12 | RES: Fxd metflm 159K 1% 1/8W | 113-1590 |
| R13 | RES: Fxd metflm 79.6K 1% 1/8W | 112-7960 |
| R14 | RES: Fxd metflm 39.8K 1% 1/8W | 112-3980 |
| R15 | RES: Fxd metflm 19.9K 1% 1/8W | 112-1990 |
| R16 | RES: Fxd metflm 159K 1% 1/8W | 113-1590 |
| R17 | RES: Fxd metflm 79.6K 1% 1/8W | 112-7960 |
| R18 | RES: Fxd metflm 39.8K 1% 1/8W | 112-3980 |
| R19 | RES: Fxd metflm 19.9K 1% 1/8W | 112-1990 |
| R20 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R21 | RES: Fxd metflm 340 ohm 1% 1/8W | 110-3400 |
| R22 | RES: Fxd metflm 159K 1% 1/8W | 113-1590 |
| R23 | RES: Fxd metflm 79.6K 1% 1/8W | 112-7960 |
| R24 | RES: Fxd metflm 39.8K 1% 1/8W | 112-3980 |
| R25 | RES: Fxd metflm 19.9K 1% 1/8W | 112-1990 |
| R26 | RES: Fxd metflm 159K 1% 1/8W | 113-1590 |
| R27 | RES: Fxd metflm 79.6K 1% 1/8W | 112-7960 |
| R28 | RES: Fxd metflm 39.8K 1% 1/8W | 112-3980 |
| R29 | RES: Fxd metflm 19.9K 1% 1/8W | 112-1990 |
| R30 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R31 | RES: Fxd metflm 887 ohm 1% 1/8W | 110-8870 |
| R32 | RES: Fxd metflm 159K 1% 1/8W | 113-1590 |
| R33 | RES: Fxd metflm 79.6K 1% 1/8W | 112-7960 |
| R34 | RES: Fxd metflm 39.8K 1% 1/8W | 112-3980 |
| R35 | RES: Fxd metflm 19.9K 1% 1/8W | 112-1990 |
| R36 | RES: Fxd metflm 159K 1% 1/8W | 113-1590 |
| R37 | RES: Fxd metflm 79.6K 1% 1/8W | 112-7960 |
| R38 | RES: Fxd metflm 39.8K 1% 1/8W | 112-3980 |
| R39 | RES: Fxd metflm 19.9K 1% 1/8W | 112-1990 |
| R40 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R41 | RES: Var cermet 20 ohm 10% | 118-0200 |
| R42 | RES: Fxd metflm 1.62K 1% 1/8W | 111-1620 |
| R43 | RES: Var cermet 20K 10% 3/4W | 118-3200 |
| R44 | RES: Fxd metflm 159K 1% 1/8W | 113-1590 |
| R45 | RES: Fxd metflm 79.6K 1% 1/8W | 112-7960 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BUTTERWORTH 1 Hz-15 KHz FILTER ASSEMBLY (02) p.n. 004-0840 (cont) | |
| R46 | RES: Fxd metflm 39.8K 1% 1/8W | 112-3980 |
| R47 | RES: Fxd metflm 19.9K 1% 1/8W | 112-1990 |
| R48 | RES: Fxd metflm 159K 1% 1/8W | 113-1590 |
| R49 | RES: Fxd metflm 79.6K 1% 1/8W | 112-7960 |
| R50 | RES: Fxd metflm 39.8K 1% 1/8W | 112-3980 |
| R51 | RES: Fxd metflm 19.9K 1% 1/8W | 112-1990 |
| R52 | RES: Fxd comp 47 ohm 5% 1/4W | 116-0471 |
| S1 | SW: Slide SPST X4 | 342-4100 |
| S2 | SW: Slide SPST X4 | 342-4100 |
| U1 | IC: Quad Bistable latch | 122-7475 |
| U2 | IC: Quad 2-input Data Sel/MLPX | 122-0112 |
| U3 | IC: Hex inverter buffer/driver O/C | 122-7406 |
| U4 | IC: Quad Bistable latch | 122-7475 |
| U5 | IC: Quad 2-input Data Sel/MLPX | 122-0112 |
| U6 | IC: Hex inverter buffer/driver O/C | 122-7406 |
| U7 | IC: Quad 2-input NAND O/C | 122-7401 |
| U8 | IC: Quad 2-input NAND O/C | 122-7401 |
| VR1 | REG: Dual $\pm$ 15 volt 100 mA | 120-0152 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BUTTERWORTH 0.1 Hz-1.5 KHz FILTER ASSEMBLY (03) p.n. 004-0850 | |
| AR1 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR2 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR3 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR4 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR5 | IC AMPL: Linear Op Amp 8007 | 120-1009 |
| C1 | CAP: Fxd tant 0.1uF 20% 35 V | 109-4100 |
| C2 | CAP: Fxd tant 0.1uF 20% 35 V | 109-4100 |
| C3 | CAP: Fxd polyester 0.0015uF 10% 100 V | 105-2150 |
| C4 | CAP: Fxd polyester 0.0015uF 10% 100 V | 105-2150 |
| C5 | CAP: Fxd elect 50uF 25 V | 109-6500 |
| C6 | CAP: Fxd cer 0.1uF +80 -20% 15 V | 100-4100 |
| C7 | CAP: Fxd tant 1uF 20% 35 V | 109-5100 |
| C8 | CAP: Fxd tant 1uF 20% 35 V | 109-5100 |
| C9 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C10 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C11 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C12 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C13 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C14 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C15 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C16 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C17 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C18 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C19 | CAP: Fxd mica dipped 100pF 10% 500 V | 101-1100 |
| C20 | CAP: Var mica 2-25pF 175 V | 108-0250 |
| C21 | CAP: Fxd mica dipped 100pF 10% 500 V | 101-1100 |
| C22 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C23 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C24 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C25 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C26 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C27 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C28 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C29 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C30 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C31 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C32 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C33 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C34 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C35 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C36 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C37 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C38 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C39 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C40 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C41 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C42 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C43 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BUTTERWORTH 0.1 Hz-1.5 KHz FILTER ASSEMBLY (03) p.n. 004-0850 (cont) | |
| C44 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C45 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C46 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C47 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C48 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C49 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C50 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C51 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C52 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C53 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C54 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C55 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C56 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C57 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C58 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C59 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C60 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C61 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| CR1 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR2 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR3 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR4 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR5 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR6 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR7 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR8 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR9 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR10 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR11 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR12 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR13 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR14 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR15 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR16 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| K1 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K2 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K3 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K4 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K5 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K6 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K7 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K8 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K9 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K10 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K11 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K12 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K13 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K14 | REL: Reed 4PST 24 V 180 mA | 175-1503 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BUTTERWORTH 0.1 Hz-1.5 KHz FILTER ASSEMBLY (03) p.n. 004-0850 (cont) | |
| K15 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K16 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| R1 | RES: Fxd comp 4.7 ohm 5% 1/4W | 116-9471 |
| R2 | RES: Fxd comp 4.7 ohm 5% 1/4W | 116-9471 |
| R3 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R4 | RES: Var cermet 50 ohm 10% | 118-0500 |
| R5 | RES: Fxd metflm 453 ohm 1% 1/8W | 110-4530 |
| R6 | RES: Fxd metflm 100K 1% 1/8W | 113-1000 |
| R7 | RES: Var cermet 20K 10% 3/4W | 118-3200 |
| R8 | RES: Fxd metflm 909K 1% 1/8W | 113-9090 |
| R9 | RES: Fxd metflm 100K 1% 1/8W | 113-1000 |
| R10 | RES: Fxd metflm 1.50K 1% 1/8W | 111-1500 |
| R11 | RES: Fxd metflm 57.6 ohm 1% 1/8W | 119-5760 |
| R12 | RES: Fxd metflm 1.59M 1% 1/8W | 114-1590 |
| R13 | RES: Fxd metflm 796K 1% 1/8W | 113-7960 |
| R14 | RES: Fxd metflm 398K 1% 1/8W | 113-3980 |
| R15 | RES: Fxd metflm 199K 1% 1/8W | 113-1990 |
| R16 | RES: Fxd metflm 1.59 | 114-1590 |
| R17 | RES: Fxd metflm 796K 1% 1/8W | 113-7960 |
| R18 | RES: Fxd metflm 398K 1% 1/8W | 113-3980 |
| R19 | RES: Fxd metflm 199K 1% 1/8W | 113-1990 |
| R20 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R21 | RES: Fxd metflm 340 ohm 1% 1/8W | 110-3400 |
| R22 | RES: Fxd metflm 1.59M 1% 1/8W | 114-1590 |
| R23 | RES: Fxd metflm 796K 1% 1/8W | 113-7960 |
| R24 | RES: Fxd metflm 398K 1% 1/8W | 113-3980 |
| R25 | RES: Fxd metflm 199K 1% 1/8W | 113-1990 |
| R26 | RES: Fxd metflm 1.59M 1% 1/8W | 114-1590 |
| R27 | RES: Fxd metflm 796K 1% 1/8W | 113-7960 |
| R28 | RES: Fxd metflm 398K 1% 1/8W | 113-3980 |
| R29 | RES: Fxd metflm 199K 1% 1/8W | 113-1990 |
| R30 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R31 | RES: Fxd metflm 887 ohm 1% 1/8W | 110-8870 |
| R32 | RES: Fxd metflm 1.59M 1% 1/8W | 114-1590 |
| R33 | RES: Fxd metflm 796K 1% 1/8W | 113-7960 |
| R34 | RES: Fxd metflm 398K 1% 1/8W | 113-3980 |
| R35 | RES: Fxd metflm 199K 1% 1/8W | 113-1990 |
| R36 | RES: Fxd metflm 1.59M 1% 1/8W | 114-1590 |
| R37 | RES: Fxd metflm 796K 1% 1/8W | 113-7960 |
| R38 | RES: Fxd metflm 398K 1% 1/8W | 113-3980 |
| R39 | RES: Fxd metflm 199K 1% 1/8W | 113-1990 |
| R40 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R41 | RES: Var cermet 20 ohm 10% | 118-0200 |
| R42 | RES: Fxd metflm 1.62K 1% 1/8W | 111-1620 |
| R43 | RES: Var cermet 20K 10% 3/4W | 118-3200 |
| R44 | RES: Fxd metflm 1.59M 1% 1/8W | 114-1590 |
| R45 | RES: Fxd metflm 796K 1% 1/8W | 113-7960 |
| R46 | RES: Fxd metflm 398K 1% 1/8W | 113-3980 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BUTTERWORTH 0.1 Hz-1.5 KHz FILTER ASSEMBLY (03) p.n. 004-0850 (cont) | |
| R47 | RES: Fxd metflm 199K 1% 1/8W | 113-1990 |
| R48 | RES: Fxd metflm 1.59M 1% 1/8W | 114-1590 |
| R49 | RES: Fxd metflm 796K 1% 1/8W | 113-7960 |
| R50 | RES: Fxd metflm 398K 1% 1/8W | 113-3980 |
| R51 | RES: Fxd metflm 199K 1% 1/8W | 113-1990 |
| R52 | RES: Fxd comp 47 ohm 5% 1/4W | 116-0471 |
| S1 | SW: Slide SPST X4 | 342-4100 |
| S2 | SW: Slide SPST X4 | 342-4100 |
| U1 | IC: Quad Bistable latch | 122-7475 |
| U2 | IC: Quad 2-input Data Sel/MLPX | 122-0112 |
| U3 | IC: Hex inverter buffer/driver O/C | 122-7406 |
| U4 | IC: Quad Bistable latch | 122-7475 |
| U5 | IC: Quad 2-input Data Sel/MLPX | 122-0112 |
| U6 | IC: Hex inverter buffer/driver O/C | 122-7406 |
| U7 | IC: Quad 2-input NAND O/C | 122-7401 |
| U8 | IC: Quad 2-input NAND O/C | 122-7401 |
| VR1 | REG: Dual $\pm$ 15 volt 100 mA | 120-0152 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BUTTERWORTH 0.01 Hz-150 Hz FILTER ASSEMBLY (04) p.n. 004-0860 | |
| AR1 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR2 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR3 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR4 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR5 | IC AMPL: Linear Op Amp 8007 | 120-1009 |
| C1 | CAP: Fxd tant 0.1uF 20% 35 V | 109-4100 |
| C2 | CAP: Fxd tant 0.1uF 20% 35 V | 109-4100 |
| C3 | CAP: Fxd polyester 0.0015uF 10% 100 V | 105-2150 |
| C4 | CAP: Fxd polyester 0.0015uF 10% 100 V | 105-2150 |
| C5 | CAP: Fxd elect 50uF 25 V | 109-6500 |
| C6 | CAP: Fxd cer 0.1uF +80 -20% 15 V | 100-4100 |
| C7 | CAP: Fxd tant 1uF 20% 35 V | 109-5100 |
| C8 | CAP: Fxd tant 1uF 20% 35 V | 109-5100 |
| C9 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C10 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C11 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C12 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C13 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C14 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C15 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C16 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C17 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C18 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C19 | CAP: Fxd mica dipped 100pF 10% 500 V | 101-1100 |
| C20 | CAP: Var mica 2-25pF 175 V | 108-0250 |
| C21 | CAP: Fxd mica dipped 100pF 10% 500 V | 101-1100 |
| C22 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C23 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C24 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C25 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C26 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C27 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C28 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C29 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C30 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C31 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C32 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C33 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C34 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C35 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C36 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C37 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C38 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C39 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C40 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C41 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C42 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C43 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BUTTERWORTH 0.01 Hz-150 Hz FILTER ASSEMBLY (04) p.n. 004-0860 (cont) | |
| C44 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C45 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C46 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C47 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C48 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C49 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C50 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C51 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C52 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C53 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C54 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C55 | CAP: Fxd mica dipped 10pF 10% 500V | 101-0100 |
| C56 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C57 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C58 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C59 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C60 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| C61 | CAP: Fxd mica dipped 10 pF 10% 500V | 101-0100 |
| CR1 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR2 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR3 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR4 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR5 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR6 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR7 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR8 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR9 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR10 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR11 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR12 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR13 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR14 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR15 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR16 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| K1 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K2 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K3 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K4 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K5 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K6 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K7 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K8 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K9 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K10 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K11 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K12 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K13 | REL: Reed 4PST 24 V 180 mA | 175-1503 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BUTTERWORTH 0.01 Hz-150 Hz FILTER ASSEMBLY (04) p.n. 004-0860 (cont) | |
| K14 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K15 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K16 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| R1 | RES: Fxd comp 4.7 ohm 5% 1/4W | 116-9471 |
| R2 | RES: Fxd comp 4.7 ohm 5% 1/4W | 116-9471 |
| R3 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R4 | RES: Var cermet 50 ohm 10% | 118-0500 |
| R5 | RES: Fxd metflm 453 ohm 1% 1/8W | 110-4530 |
| R6 | RES: Fxd metflm 100K 1% 1/8W | 113-1000 |
| R7 | RES: Var cermet 20K 10% 3/4W | 118-3200 |
| R8 | RES: Fxd metflm 909K 1% 1/8W | 113-9090 |
| R9 | RES: Fxd metflm 100K 1% 1/8W | 113-1000 |
| R10 | RES: Fxd metflm 1.50K 1% 1/8W | 111-1500 |
| R11 | RES: Fxd metflm 57.6 ohm 1% 1/8W | 119-5760 |
| R12 | RES: Fxd metflm 15.9M 1% 1/8W | 115-1590 |
| R13 | RES: Fxd metflm 7.96M 1% 1/8W | 114-7960 |
| R14 | RES: Fxd metflm 3.98M 1% 1/8W | 114-3980 |
| R15 | RES: Fxd metflm 1.99M 1% 1/8W | 114-1990 |
| R16 | RES: Fxd metflm 15.9M 1% 1/8W | 115-1590 |
| R17 | RES: Fxd metflm 7.96M 1% 1/8W | 114-7960 |
| R18 | RES: Fxd metflm 3.98M 1% 1/8W | 114-3980 |
| R19 | RES: Fxd metflm 1.99M 1% 1/8W | 114-1990 |
| R20 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R21 | RES: Fxd metflm 340 ohm 1% 1/8W | 110-3400 |
| R22 | RES: Fxd metflm 15.9M 1% 1/8W | 115-1590 |
| R23 | RES: Fxd metflm 7.96M 1% 1/8W | 114-7960 |
| R24 | RES: Fxd metflm 3.98M 1% 1/8W | 114-3980 |
| R25 | RES: Fxd metflm 1.99M 1% 1/8W | 114-1990 |
| R26 | RES: Fxd metflm 15.9M 1% 1/8W | 115-1590 |
| R27 | RES: Fxd metflm 7.96M 1% 1/8W | 114-7960 |
| R28 | RES: Fxd metflm 3.98M 1% 1/8W | 114-3980 |
| R29 | RES: Fxd metflm 1.99M 1% 1/8W | 114-1990 |
| R30 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R31 | RES: Fxd metflm 887 ohm 1% 1/8W | 110-8870 |
| R32 | RES: Fxd metflm 15.9M 1% 1/8W | 115-1590 |
| R33 | RES: Fxd metflm 7.96M 1% 1/8W | 114-7960 |
| R34 | RES: Fxd metflm 3.98M 1% 1/8W | 114-3980 |
| R35 | RES: Fxd metflm 1.99M 1% 1/8W | 114-1990 |
| R36 | RES: Fxd metflm 15.9M 1% 1/8W | 115-1590 |
| R37 | RES: Fxd metflm 7.96M 1% 1/8W | 114-7960 |
| R38 | RES: Fxd metflm 3.98M 1% 1/8W | 114-3980 |
| R39 | RES: Fxd metflm 1.99M 1% 1/8W | 114-1990 |
| R40 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R41 | RES: Var cermet 20 ohm 10% | 118-0200 |
| R42 | RES: Fxd metflm 1.62K 1% 1/8W | 111-1620 |
| R43 | RES: Var cermet 20K 10% 3/4W | 118-3200 |
| R44 | RES: Fxd metflm 15.9M 1% 1/8W | 115-1590 |
| R45 | RES: Fxd metflm 7.96M 1% 1/8W | 114-7960 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BUTTERWORTH 0.01 Hz-150 Hz FILTER ASSEMBLY (04) p.n. 004-0860 (cont) | |
| R46 | RES: Fxd metflm 3.98M 1% 1/8W | 114-3980 |
| R47 | RES: Fxd metflm 1.99M 1% 1/8W | 114-1990 |
| R48 | RES: Fxd metflm 15.9M 1% 1/8W | 115-1590 |
| R49 | RES: Fxd metflm 7.96M 1% 1/8W | 114-7960 |
| R50 | RES: Fxd metflm 3.98M 1% 1/8W | 114-3980 |
| R51 | RES: Fxd metflm 1.99M 1% 1/8W | 114-1990 |
| R52 | RES: Fxd comp 47 ohm 5% 1/4W | 116-0471 |
| S1 | SW: Slide SPST X4 | 342-4100 |
| S2 | SW: Slide SPST X4 | 342-4100 |
| U1 | IC: Quad Bistable latch | 122-7475 |
| U2 | IC: Quad 2-input Data Sel/MLPX | 122-0112 |
| U3 | IC: Hex inverter buffer/driver O/C | 122-7406 |
| U4 | IC: Quad Bistable latch | 122-7475 |
| U5 | IC: Quad 2-input Data Sel/MLPX | 122-0112 |
| U6 | IC: Hex inverter buffer/driver O/C | 122-7406 |
| U7 | IC: Quad 2-input NAND O/C | 122-7401 |
| U8 | IC: Quad 2-input NAND O/C | 122-7401 |
| VR1 | REG: Dual $\pm$ 15 volt 100 mA | 120-0152 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BESSEL 10 Hz-150 KHz FILTER ASSEMBLY (05) p.n. 004-0835 | |
| AR1 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR2 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR3 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR4 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR5 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| C1 | CAP: Fxd tant 0.1uF 20% 35 V | 109-4100 |
| C2 | CAP: Fxd tant 0.1uF 20% 35 V | 109-4100 |
| C3 | CAP: Fxd polyester 0.0015uF 10% 100 V | 105-2150 |
| C4 | CAP: Fxd polyester 0.0015uF 10% 100 V | 105-2150 |
| C5 | CAP: Fxd elect 50uF 25 V | 109-6500 |
| C6 | CAP: Fxd cer 0.1uF +80 -20% 15 V | 100-4100 |
| C7 | CAP: Fxd tant 1uF 20% 35 V | 109-5100 |
| C8 | CAP: Fxd tant 1uF 20% 35 V | 109-5100 |
| C9 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C10 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C11 | CAP: Fxd cer 0 ..01uF +80 -20% 30 V | 100-3101 |
| C12 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C13 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C14 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C15 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C16 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C17 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C18 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C19 | CAP: Fxd mica dipped 100pF 10% 500 V | 101-1100 |
| C20 | CAP: Var mica 2-25pF 175 V | 108-0250 |
| C21 | CAP: Fxd mica dipped 100pF 10% 500 V | 101-1100 |
| C22 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C23 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C24 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C25 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C26 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C27 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C28 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C29 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C30 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C31 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C32 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C33 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C34 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C35 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C36 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C37 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C38 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C39 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C40 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C41 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C42 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C43 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BESSEL 10 Hz-150 KHz FILTER ASSEMBLY (05) p.n. 004-0835 (cont) | |
| C44 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C45 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C46 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C47 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C48 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C49 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C50 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C51 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C52 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C53 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C54 | CAP: Fxd mica dipped 47 pF 10% 500V | 101-0470 |
| C55 | CAP: Fxd mica dipped 47 pF 10% 500V | 101-0470 |
| C56 | CAP: Fxd mica dipped 47 pF 10% 500V | 101-0470 |
| C57 | CAP: Fxd mica dipped 47 pF 10% 500V | 101-0470 |
| C58 | CAP: Fxd mica dipped 47 pF 10% 500V | 101-0470 |
| C59 | CAP: Fxd mica dipped 47 pF 10% 500V | 101-0470 |
| C60 | CAP: Fxd mica dipped 47 pF 10% 500V | 101-0470 |
| C61 | CAP: Fxd mica dipped 47 pF 10% 500V | 101-0470 |
| CR1 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR2 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR3 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR4 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR5 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR6 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR7 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR8 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR9 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR10 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR11 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR12 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR13 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR14 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR15 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR16 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| K1 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K2 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K3 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K4 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K5 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K6 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K7 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K8 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K9 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K10 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K11 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K12 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K13 | REL: Reed 4PST 24 V 180 mA | 175-1503 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BESSEL 10 Hz-150 KHz FILTER ASSEMBLY (05) p.n. 004-0835 (cont) | |
| K14 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K15 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K16 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| R1 | RES: Fxd comp 4.7 ohm 5% 1/4W | 116-9471 |
| R2 | RES: Fxd comp 4.7 ohm 5% 1/4W | 116-9471 |
| R3 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R4 | RES: Var cermet 50 ohm 10% | 118-0500 |
| R5 | RES: Fxd metflm 1.33K 1% 1/8W | 111-1330 |
| R6 | RES: Fxd metflm 100K 1% 1/8W | 113-1000 |
| R7 | RES: Var cermet 20K 10% 3/4W | 118-3200 |
| R8 | RES: Fxd metflm 909K 1% 1/8W | 113-9090 |
| R9 | RES: Fxd metflm 100K 1% 1/8W | 113-1000 |
| R10 | RES: Fxd metflm 2K 1% 1/8W | 111-2000 |
| R11 | RES: Fxd metflm 47.5 ohm 1% 1/8W | 119-4750 |
| R12 | RES: Fxd metflm 17.8K 1% 1/8W | 112-1780 |
| R13 | RES: Fxd metflm 8.87K 1% 1/8W | 111-8870 |
| R14 | RES: Fxd metflm 4.42K 1% 1/8W | 111-4420 |
| R15 | RES: Fxd metflm 2.21K 1% 1/8W | 111-2210 |
| R16 | RES: Fxd metflm 17.8K 1% 1/8W | 112-1780 |
| R17 | RES: Fxd metflm 8.87K 1% 1/8W | 111-8870 |
| R18 | RES: Fxd metflm 4.42K 1% 1/8W | 111-4420 |
| R19 | RES: Fxd metflm 2.21K 1% 1/8W | 111-2210 |
| R20 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R21 | RES: Fxd metflm 210 ohm 1% 1/8W | 110-2100 |
| R22 | RES: Fxd metflm 17.4K 1% 1/8W | 112-1740 |
| R23 | RES: Fxd metflm 8.66K 1% 1/8W | 111-8660 |
| R24 | RES: Fxd metflm 4.32K 1% 1/8W | 111-4320 |
| R25 | RES: Fxd metflm 2.15K 1% 1/8W | 111-2150 |
| R26 | RES: Fxd metflm 17.4K 1% 1/8W | 112-1740 |
| R27 | RES: Fxd metflm 8.66K 1% 1/8W | 111-8660 |
| R28 | RES: Fxd metflm 4.32K 1% 1/8W | 111-4320 |
| R29 | RES: Fxd metflm 2.15K 1% 1/8W | 111-2150 |
| R30 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R31 | RES: Fxd metflm 590 ohm 1% 1/8W | 110-5900 |
| R32 | RES: Fxd metflm 16.2K 1% 1/8W | 112-1620 |
| R33 | RES: Fxd metflm 8.06K 1% 1/8W | 111-8060 |
| R34 | RES: Fxd metflm 4.02K 1% 1/8W | 111-4020 |
| R35 | RES: Fxd metflm 2.05K 1% 1/8W | 111-2050 |
| R36 | RES: Fxd metflm 16.2K 1% 1/8W | 112-1620 |
| R37 | RES: Fxd metflm 8.06K 1% 1/8W | 111-8060 |
| R38 | RES: Fxd metflm 4.02K 1% 1/8W | 111-4020 |
| R39 | RES: Fxd metflm 2.05K 1% 1/8W | 111-2050 |
| R40 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R41 | RES: Var cermet 20 ohm 10% | 118-0200 |
| R42 | RES: Fxd metflm 1.18K 1% 1/8W | 111-1180 |
| R43 | RES: Var cermet 20K 10% 3/4W | 118-3200 |
| R44 | RES: Fxd metflm 14.3K 1% 1/8W | 112-1430 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BESSEL 10 Hz-150 KHz FILTER ASSEMBLY (05) p.n. 004-0835 (cont) | |
| R45 | RES: Fxd metflm 7.32K 1% 1/8W | 111-7320 |
| R46 | RES: Fxd metflm 3.57K 1% 1/8W | 111-3570 |
| R47 | RES: Fxd metflm 1.82K 1% 1/8W | 111-1820 |
| R48 | RES: Fxd metflm 14.3K 1% 1/8W | 112-1430 |
| R49 | RES: Fxd metflm 7.32K 1% 1/8W | 111-7320 |
| R50 | RES: Fxd metflm 3.57K 1% 1/8W | 111-3570 |
| R51 | RES: Fxd metflm 1.82K 1% 1/8W | 111-1820 |
| R52 | RES: Fxd comp 47 ohm 5% 1/4W | 116-0471 |
| S1 | SW: Slide SPST X4 | 342-4100 |
| S2 | SW: Slide SPST X4 | 342-4100 |
| U1 | IC: Quad Bistable latch | 122-7475 |
| U2 | IC: Quad 2-input Data Sel/MLPX | 122-0112 |
| U3 | IC: Hex inverter buffer/driver O/C | 122-7406 |
| U4 | IC: Quad Bistable latch | 122-7475 |
| U5 | IC: Quad 2-input Data Sel/MLPX | 122-0112 |
| U6 | IC: Hex inverter buffer/driver O/C | 122-7406 |
| U7 | IC: Quad 2-input NAND O/C | 122-7401 |
| U8 | IC: Quad 2-input NAND O/C | 122-7401 |
| VR1 | REG: Dual $\pm$ 15 volt 100 mA | 120-0152 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BESSEL 1 Hz- 15 KHz FILTER ASSEMBLY (06) p.n. 004-0845 | |
| AR1 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR2 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR3 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR4 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR5 | IC AMPL: Linear Op Amp 8007 | 120-1009 |
| C1 | CAP: Fxd tant 0.1uF 20% 35 V | 109-4100 |
| C2 | CAP: Fxd tant 0.1uF 20% 35 V | 109-4100 |
| C3 | CAP: Fxd polyester 0.0015uF 10% 100 V | 105-2150 |
| C4 | CAP: Fxd polyester 0.0015uF 10% 100 V | 105-2150 |
| C5 | CAP: Fxd elect 50uF 25 V | 109-6500 |
| C6 | CAP: Fxd cer 0.1uF +80 -20% 15 V | 100-4100 |
| C7 | CAP: Fxd tant 1uF 20% 35 V | 109-5100 |
| C8 | CAP: Fxd tant 1uF 20% 35 V | 109-5100 |
| C9 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C10 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C11 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C12 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C13 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C14 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C15 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C16 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C17 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C18 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C19 | CAP: Fxd mica dipped 100pF 10% 500 V | 101-1100 |
| C20 | CAP: Var mica 2-25pF 175 V | 108-0250 |
| C21 | CAP: Fxd mica dipped 100pF 10% 500 V | 101-1100 |
| C22 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C23 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C24 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C25 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C26 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C27 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C28 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C29 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C30 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C31 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C32 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C33 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C34 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C35 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C36 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C37 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C38 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C39 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C40 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C41 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C42 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C43 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BESSEL 1 Hz-15 KHz FILTER ASSEMBLY (06) p.n. 004-0845 (cont) | |
| C44 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C45 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C46 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C47 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C48 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C49 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C50 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C51 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C52 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C53 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C54 | CAP: Fxd mica dipped 47pF 10% 500 V | 101-0470 |
| C55 | CAP: Fxd mica dipped 47pF 10% 500 V | 101-0470 |
| C56 | CAP: Fxd mica dipped 47pF 10% 500 V | 101-0470 |
| C57 | CAP: Fxd mica dipped 47pF 10% 500 V | 101-0470 |
| C58 | CAP: Fxd mica dipped 47pF 10% 500 V | 101-0470 |
| C59 | CAP: Fxd mica dipped 47pF 10% 500 V | 101-0470 |
| C60 | CAP: Fxd mica dipped 47pF 10% 500 V | 101-0470 |
| C61 | CAP: Fxd mica dipped 47pF 10% 500 V | 101-0470 |
| CR1 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR2 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR3 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR4 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR5 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR6 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR7 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR8 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR9 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR10 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR11 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR12 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR13 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR14 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR15 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR16 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| K1 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K2 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K3 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K4 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K5 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K6 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K7 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K8 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K9 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K10 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K11 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K12 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K13 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K14 | REL: Reed 4PST 24 V 180 mA | 175-1503 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BESSEL 1 Hz-15 KHz FILTER ASSEMBLY (06) p.n. 004-0845 (cont) | |
| K15 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K16 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| R1 | RES: Fxd comp 4.7 ohm 5% 1/4W | 116-9471 |
| R2 | RES: Fxd comp 4.7 ohm 5% 1/4W | 116-9471 |
| R3 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R4 | RES: Var cermet 50 ohm 10% | 118-0500 |
| R5 | RES: Fxd metflm 1.33K 1% 1/8W | 111-1330 |
| R6 | RES: Fxd metflm 100K 1% 1/8W | 113-1000 |
| R7 | RES: Var cermet 20K 10% 3/4W | 118-3200 |
| R8 | RES: Fxd metflm 909K 1% 1/8W | 113-9090 |
| R9 | RES: Fxd metflm 100K 1% 1/8W | 113-1000 |
| R10 | RES: Fxd metflm 2K 1% 1/8W | 111-2000 |
| R11 | RES: Fxd metflm 47.5 ohm 1% 1/8W | 119-4750 |
| R12 | RES: Fxd metflm 178K 1% 1/8W | 113-1780 |
| R13 | RES: Fxd metflm 88.7K 1% 1/8W | 112-8870 |
| R14 | RES: Fxd metflm 44.2K 1% 1/8W | 112-4420 |
| R15 | RES: Fxd metflm 22.1K 1% 1/8W | 112-2210 |
| R16 | RES: Fxd metflm 178K 1% 1/8W | 113-1780 |
| R17 | RES: Fxd metflm 88.7K 1% 1/8W | 112-8870 |
| R18 | RES: Fxd metflm 44.2K 1% 1/8W | 112-4420 |
| R19 | RES: Fxd metflm 22.1K 1% 1/8W | 112-2210 |
| R20 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R21 | RES: Fxd metflm 210 ohm 1% 1/8W | 110-2100 |
| R22 | RES: Fxd metflm 174K 1% 1/8W | 113-1740 |
| R23 | RES: Fxd metflm 86.6K 1% 1/8W | 112-8660 |
| R24 | RES: Fxd metflm 43.2K 1% 1/8W | 112-4320 |
| R25 | RES: Fxd metflm 21.5K 1% 1/8W | 112-2150 |
| R26 | RES: Fxd metflm 174K 1% 1/8W | 113-1740 |
| R27 | RES: Fxd metflm 86.6K 1% 1/8W | 112-8660 |
| R28 | RES: Fxd metflm 43.2K 1% 1/8W | 112-4320 |
| R29 | RES: Fxd metflm 21.5K 1% 1/8W | 112-2150 |
| R30 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R31 | RES: Fxd metflm 590 ohm 1% 1/8W | 110-5900 |
| R32 | RES: Fxd metflm 162K 1% 1/8W | 113-1620 |
| R33 | RES: Fxd metflm 80.6K 1% 1/8W | 112-8060 |
| R34 | RES: Fxd metflm 40.2K 1% 1/8W | 112-4020 |
| R35 | RES: Fxd metflm 20.5K 1% 1/8W | 112-2050 |
| R36 | RES: Fxd metflm 162K 1% 1/8W | 113-1620 |
| R37 | RES: Fxd metflm 80.6K 1% 1/8W | 112-8060 |
| R38 | RES: Fxd metflm 40.2K 1% 1/8W | 112-4020 |
| R39 | RES: Fxd metflm 20.5K 1% 1/8W | 112-2050 |
| R40 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R41 | RES: Var cermet 20 ohm 10% | 118-0200 |
| R42 | RES: Fxd metflm 1.18K 1% 1/8W | 111-1180 |
| R43 | RES: Var cermet 20K 10% 3/4W | 118-3200 |
| R44 | RES: Fxd metflm 143K 1% 1/8W | 113-1430 |
| R45 | RES: Fxd metflm 73.2K 1% 1/8W | 112-7320 |
| R46 | RES: Fxd metflm 35.7K 1% 1/8W | 112-3570 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BESSEL 1 Hz-15 KHz FILTER ASSEMBLY (06) p.n. 004-0845 (cont) | |
| R47 | RES: Fxd metflm 18.2K 1% 1/8W | 112-1820 |
| R48 | RES: Fxd metflm 143K 1% 1/8W | 113-1430 |
| R49 | RES: Fxd metflm 73.2K 1% 1/8W | 112-7320 |
| R50 | RES: Fxd metflm 35.7K 1% 1/8W | 112-3570 |
| R51 | RES: Fxd metflm 18.2K 1% 1/8W | 112-1820 |
| R52 | RES: Fxd comp 47 ohm 5% 1/4W | 116-0471 |
| S1 | SW: Slide SPST X4 | 342-4100 |
| S2 | SW: Slide SPST X4 | 342-4100 |
| U1 | IC: Quad Bistable latch | 122-7475 |
| U2 | IC: Quad 2-input Data Sel/MLPX | 122-0112 |
| U3 | IC: Hex inverter buffer/driver O/C | 122-7406 |
| U4 | IC: Quad Bistable latch | 122-7475 |
| U5 | IC: Quad 2-input Data Sel/MLPX | 122-0112 |
| U6 | IC: Hex inverter buffer/driver O/C | 122-7406 |
| U7 | IC: Quad 2-input NAND O/C | 122-7401 |
| U8 | IC: Quad 2-input NAND O/C | 122-7401 |
| VR1 | REG: Dual $\pm$ 15 volt 100 mA | 120-0152 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BESSEL 0.1 Hz-1.5 KHz FILTER ASSEMBLY (07) p.n. 004-0855 | |
| AR1 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR2 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR3 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR4 | IC AMPL: Linear Op Amp HA-2515-5 | 120-1002 |
| AR5 | IC AMPL: Linear Op Amp 8007 | 120-1009 |
| C1 | CAP: Fxd tant 0.1uF 20% 35 V | 109-4100 |
| C2 | CAP: Fxd tant 0.1uF 20% 35 V | 109-4100 |
| C3 | CAP: Fxd polyester 0.0015uF 10% 100 V | 105-2150 |
| C4 | CAP: Fxd polyester 0.0015uF 10% 100 V | 105-2150 |
| C5 | CAP: Fxd elect 50uF 25 V | 109-6500 |
| C6 | CAP: Fxd cer 0.1uF +80 -20% 15 V | 100-4100 |
| C7 | CAP: Fxd tant 1uF 20% 35 V | 109-5100 |
| C8 | CAP: Fxd tant 1uF 20% 35 V | 109-5100 |
| C9 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C10 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C11 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C12 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C13 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C14 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C15 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C16 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C17 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C18 | CAP: Fxd cer 0 . 01uF +80 -20% 30 V | 100-3101 |
| C19 | CAP: Fxd mica dipped 100pF 10% 500 V | 101-1100 |
| C20 | CAP: Var mica 2-25pF 175 V | 108-0250 |
| C21 | CAP: Fxd mica dipped 100pF 10% 500 V | 101-1100 |
| C22 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C23 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C24 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C25 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C26 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C27 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C28 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C29 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C30 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C31 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C32 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C33 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C34 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C35 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C36 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C37 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C38 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C39 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C40 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C41 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C42 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C43 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C44 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BESSEL 0.1 Hz-1.5 KHz FILTER ASSEMBLY (07) p.n. 004-0855 (cont) | |
| C45 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C46 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C47 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C48 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C49 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C50 | CAP: Fxd polycarb molded 1uF 1% 100 V | 104-5100 |
| C51 | CAP: Fxd polycarb molded 0.1uF 1% 100 V | 104-4100 |
| C52 | CAP: Fxd polycarb molded 0.01uF 1% 100 V | 104-3100 |
| C53 | CAP: Fxd mica molded 910pF 1% 500 V | 102-1910 |
| C54 | CAP: Fxd mica dipped 47pF 10% 500 V | 101-0470 |
| C55 | CAP: Fxd mica dipped 47pF 10% 500 V | 101-0470 |
| C56 | CAP: Fxd mica dipped 47pF 10% 500 V | 101-0470 |
| C57 | CAP: Fxd mica dipped 47pF 10% 500 V | 101-0470 |
| C58 | CAP: Fxd mica dipped 47pF 10% 500 V | 101-0470 |
| C59 | CAP: Fxd mica dipped 47pF 10% 500 V | 101-0470 |
| C60 | CAP: Fxd mica dipped 47pF 10% 500 V | 101-0470 |
| C61 | CAP: Fxd mica dipped 47pF 10% 500 V | 101-0470 |
| CR1 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR2 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR3 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR4 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR5 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR6 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR7 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR8 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR9 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR10 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR11 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR12 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR13 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR14 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR15 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| CR16 | DIO: Sil low leak 70 PIV 200 mA | 132-0457 |
| K1 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K2 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K3 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K4 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K5 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K6 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K7 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K8 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K9 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K10 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K11 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K12 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K13 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K14 | REL: Reed 4PST 24 V 180 mA | 175-1503 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BESSEL 0.1 Hz-1.5 KHz FILTER ASSEMBLY (07) p.n. 004-0855 (cont) | |
| K15 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| K16 | REL: Reed 4PST 24 V 180 mA | 175-1503 |
| R1 | RES: Fxd comp 4.7 ohm 5% 1/4W | 116-9471 |
| R2 | RES: Fxd comp 4.7 ohm 5% 1/4W | 116-9471 |
| R3 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R4 | RES: Var cermet 50 ohm 10% | 118-0500 |
| R5 | RES: Fxd metflm 1.33K 1% 1/8W | 111-1330 |
| R6 | RES: Fxd metflm 100K 1% 1/8W | 113-1000 |
| R7 | RES: Var cermet 20K 10% 3/4W | 118-3200 |
| R8 | RES: Fxd metflm 909K 1% 1/8W | 113-9090 |
| R9 | RES: Fxd metflm 100K 1% 1/8W | 113-1000 |
| R10 | RES: Fxd metflm 2K 1% 1/8W | 111-2000 |
| R11 | RES: Fxd metflm 47.5 ohm 1% 1/8W | 119-4750 |
| R12 | RES: Fxd metflm 1.78M 1% 1/8W | 114-1780 |
| R13 | RES: Fxd metflm 887K 1% 1/8W | 113-8870 |
| R14 | RES: Fxd metflm 442K 1% 1/8W | 113-4420 |
| R15 | RES: Fxd metflm 221K 1% 1/8W | 113-2210 |
| R16 | RES: Fxd metflm 1.78M 1% 1/8W | 114-1780 |
| R17 | RES: Fxd metflm 887K 1% 1/8W | 113-8870 |
| R18 | RES: Fxd metflm 442K 1% 1/8W | 113-4420 |
| R19 | RES: Fxd metflm 221K 1% 1/8W | 113-2210 |
| R20 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R21 | RES: Fxd metflm 210 ohm 1% 1/8W | 110-2100 |
| R22 | RES: Fxd metflm 1.74M 1% 1/8W | 114-1740 |
| R23 | RES: Fxd metflm 866K 1% 1/8W | 113-8660 |
| R24 | RES: Fxd metflm 432K 1% 1/8W | 113-4320 |
| R25 | RES: Fxd metflm 215K 1% 1/8W | 113-2150 |
| R26 | RES: Fxd metflm 1.74M 1% 1/8W | 114-1740 |
| R27 | RES: Fxd metflm 866K 1% 1/8W | 113-8660 |
| R28 | RES: Fxd metflm 432K 1% 1/8W | 113-4320 |
| R29 | RES: Fxd metflm 215K 1% 1/8W | 113-2150 |
| R30 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R31 | RES: Fxd metflm 590 ohm 1% 1/8W | 110-5900 |
| R32 | RES: Fxd metflm 1.62M 1% 1/8W | 114-1620 |
| R33 | RES: Fxd metflm 806K 1% 1/8W | 113-8060 |
| R34 | RES: Fxd metflm 402K 1% 1/8W | 113-4020 |
| R35 | RES: Fxd metflm 205K 1% 1/8W | 113-2050 |
| R36 | RES: Fxd metflm 1.62M 1% 1/8W | 114-1620 |
| R37 | RES: Fxd metflm 806K 1% 1/8W | 113-8060 |
| R38 | RES: Fxd metflm 402K 1% 1/8W | 113-4020 |
| R39 | RES: Fxd metflm 205K 1% 1/8W | 113-2050 |
| R40 | RES: Fxd metflm 1.00K 1% 1/8W | 111-1000 |
| R41 | RES: Var cermet 20 ohm 10% | 118-0200 |
| R42 | RES: Fxd metflm 1.18K 1% 1/8W | 111-1180 |
| R43 | RES: Var cermet 20K 10% 3/4W | 118-3200 |
| R44 | RES: Fxd metflm 1.43M 1% 1/8W | 114-1430 |
| R45 | RES: Fxd metflm 732K 1% 1/8W | 113-7320 |
| R46 | RES: Fxd metflm 357K 1% 1/8W | 113-3570 |

| REF. DES. | DESCRIPTION | PART NO. |
|---|---|---|
| | BESSEL 0.1 Hz-1.5 KHz FILTER ASSEMBLY (07) p.n. 004-0855 (cont) | |
| R47 | RES: Fxd metflm 182K 1% 1/8W | 113-1820 |
| R48 | RES: Fxd metflm 1.43M 1% 1/8W | 114-1430 |
| R49 | RES: Fxd metflm 732K 1% 1/8W | 113-7320 |
| R50 | RES: Fxd metflm 357K 1% 1/8W | 113-3570 |
| R51 | RES: Fxd metflm 182K 1% 1/8W | 113-1820 |
| R52 | RES: Fxd comp 47 ohm 5% 1/4W | 116-0471 |
| S1 | SW: Slide SPST X4 | 342-4100 |
| S2 | SW: Slide SPST X4 | 342-4100 |
| U1 | IC: Quad Bistable latch | 122-7475 |
| U2 | IC: Quad 2-input Data Sel/MLPX | 122-0112 |
| U3 | IC: Hex inverter buffer/driver O/C | 122-7406 |
| U4 | IC: Quad Bistable latch | 122-7475 |
| U5 | IC: Quad 2-input Data Sel/MLPX | 122-0112 |
| U6 | IC: Hex inverter buffer/driver O/C | 122-7406 |
| U7 | IC: Quad 2-input NAND O/C | 122-7401 |
| U8 | IC: Quad 2-input NAND O/C | 122-7401 |
| VR1 | REG: Dual ±15 volt 100mA | 120-0152 |

# SECTION VI
# DIAGRAMS

## 6-1. INTRODUCTION.

This section contains component-location illustrations and schematics for System 816. In addition, pin connection drawings and truth tables are provided for each of the integrated-circuit packages used in System 816.

The component-location illustrations identify, by reference designation, the location of all electrical components shown on the schematics. System 816 is divided into three sections for schematic purposes. The schematics are drawn to standards provided in USAS Y32.16-1968 and ANSI Y32.2-1970 (IEEE No. 315).

The first schematic applies to the power supply. Most of the components shown on the power supply schematic are mounted on the motherboard. Some power supply components are mounted on the rear and side panels, and the POWER Switch is mounted on the front-panel scanner assembly. The motherboard also contains the sockets for the plug-in scanner assembly and filter cards.

The second schematic applies to the scanner assembly. The scanner assembly is designated A1, and the two sockets into which it fits are designated XA1A and XA1B.

The third schematic applies to the filter card assemblies. The filter cards are designated A2 (Channel 0) through A17 (Channel 15), and the two sockets into which each filter card fits are designated XA2A and XA2B through XA17A and XA17B. Table 6-1 lists the values for those components which differ among the different types of filter cards.

The motherboard has three printed-circuit-edge connectors to which signals are connected at the rear panel. The PROGRAMMING Connector is designated J1, the CHANNEL 0-7

Connector is designated J2, and the CHANNEL 8-15 Connector is designated J3.

All but one of the power supply outputs are supplied to bus lines which connect to the sockets for the sixteen filter cards. The addresses of these bus lines are shown on the power supply schematic, and the bus lines are labeled on the bottom side of the mother-board. Connections between the rear-panel connectors and the plug-in assemblies can be determined by comparing the schematics to the connector tables in Section 2. Other connections between assemblies are listed in parentheses next to the pin designations on the schematics.

All components shown on the schematics and component-location illustrations are described in the parts list in Section 5. Any replacement parts required should be selected from the parts list.

Table 6-1. Filter Card Component Values.

| | 10 Hz-150 KHz | 1 Hz-15 KHz | 0.1 Hz-1.5 KHz | 0.01 Hz-150 Hz |
|---|---|---|---|---|
| Butterworth | 01 | 02 | 03 | 04 |
| R12, R16, R22, R26, R32, R36, R44, R48 | 15.9K | 159K | 1.59M | 15.9M |
| R13, R17, R23, R27, R33, R37, R45, R49 | 7.96K | 79.6K | 796K | 7.96M |
| R14, R18, R24, R28, R34, R38, R46, R50 | 3.98K | 39.8K | 398K | 3.98M |
| R15, R19, R25, R29, R35, R39, R47, R51 | 1.99K | 19.9K | 199K | 1.99M |
| | | | | |
| Bessel | 05 | 06 | 07 | |
| R12, R16 | 17.8K | 178K | 1.78M | |
| R22, R26 | 17.4K | 174K | 1.74M | |
| R32, R36 | 16.2K | 162K | 1.62M | |
| R44, R48 | 14.3K | 142K | 1.43M | |
| R13, R17 | 8.87K | 88.7K | 887K | |
| R23, R27 | 8.66K | 86.6K | 866K | |
| R33, R37 | 8.06K | 80.6K | 806K | |
| R45, R49 | 7.32K | 73.2K | 732K | |
| R14, R18 | 4.42K | 44.2K | 442K | |
| R24, R28 | 4.32K | 43.2K | 432K | |
| R34, R38 | 4.02K | 40.2K | 402K | |
| R46, R50 | 3.57K | 35.7K | 357K | |
| R15, R19 | 2.21K | 22.1K | 221K | |
| R25, R29 | 2.15K | 21.5K | 215K | |
| R35, R39 | 2.05K | 20.5K | 205K | |
| R47, R51 | 1.82K | 18.2K | 182K | |

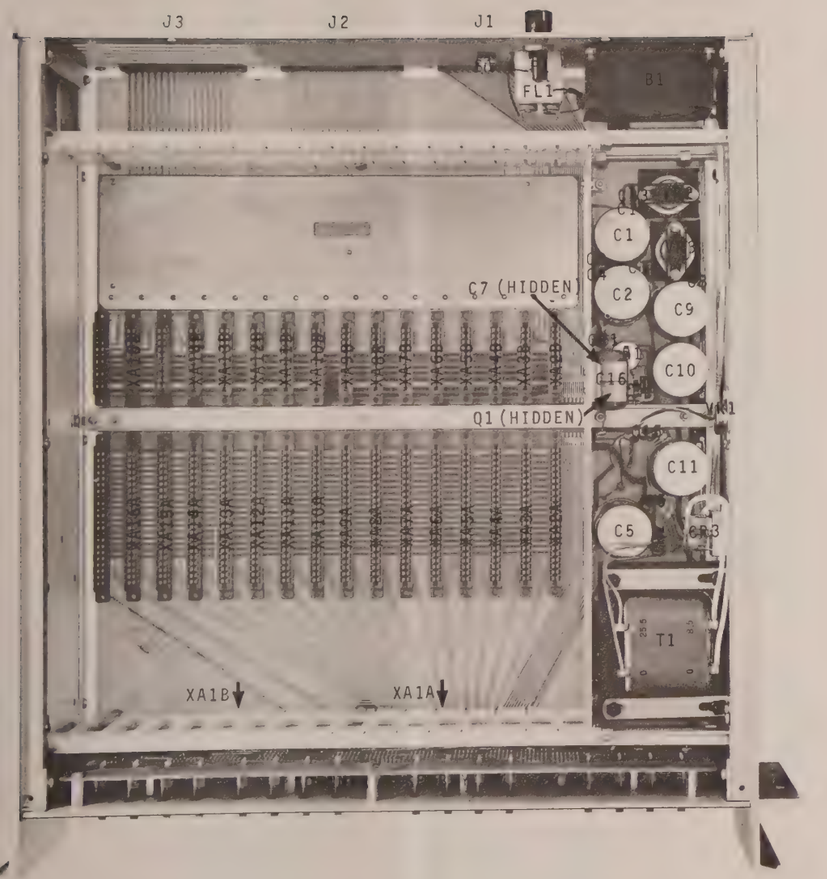
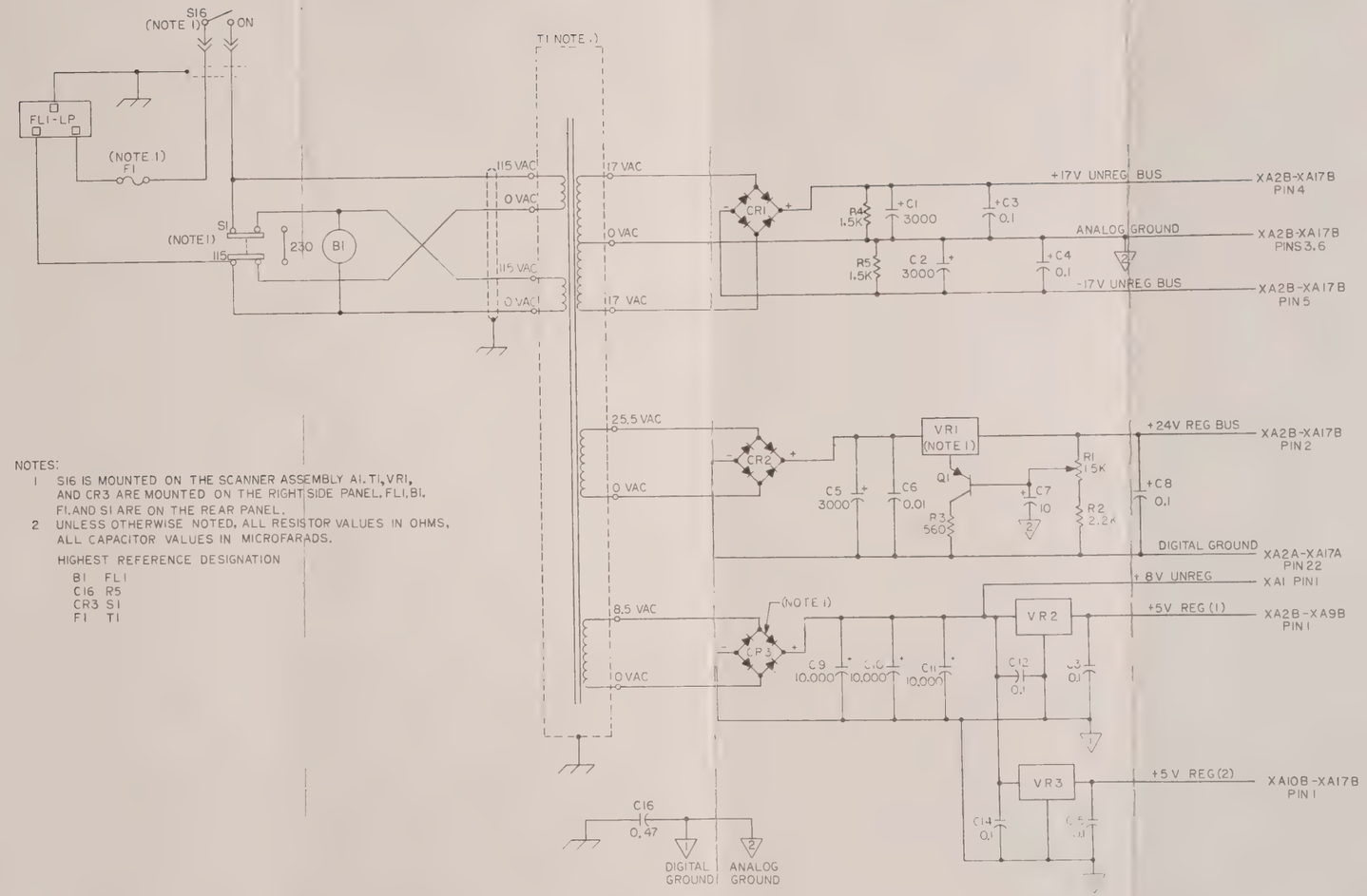



Figure 6-1. Motherboard And Chassis Component Locations.



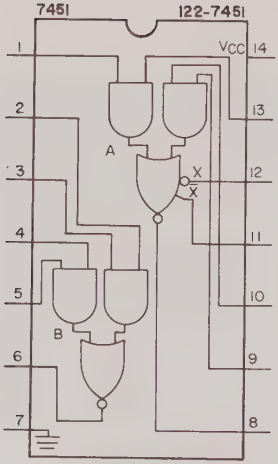

NOTES:

1. S16 IS MOUNTED ON THE SCANNER ASSEMBLY A1. T1, VR1, AND CR3 ARE MOUNTED ON THE RIGHT SIDE PANEL. FL1, B1, F1, AND S1 ARE ON THE REAR PANEL.
2. UNLESS OTHERWISE NOTED, ALL RESISTOR VALUES IN OHMS, ALL CAPACITOR VALUES IN MICROFARADS.

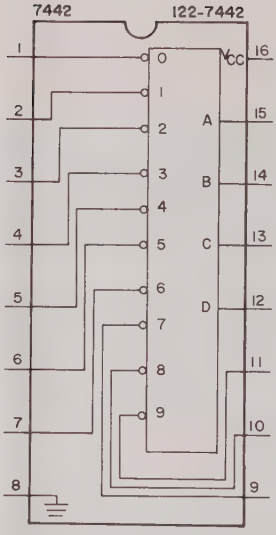
HIGHEST REFERENCE DESIGNATION

| | |
|---|---|
| B1 | FL1 |
| C16 | R5 |
| CR3 | S1 |
| F1 | T1 |

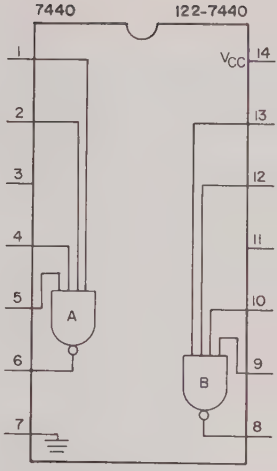
Figure 6-2. Power Supply Schematic.



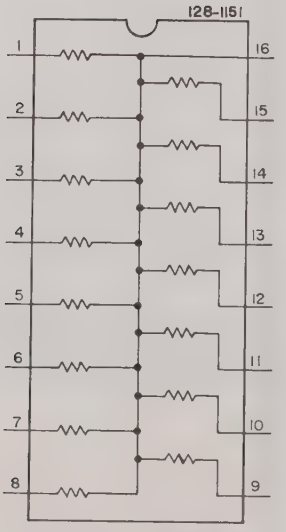

DUAL 2-WIDE 2-INPUT
AND-OR INVERT GATE



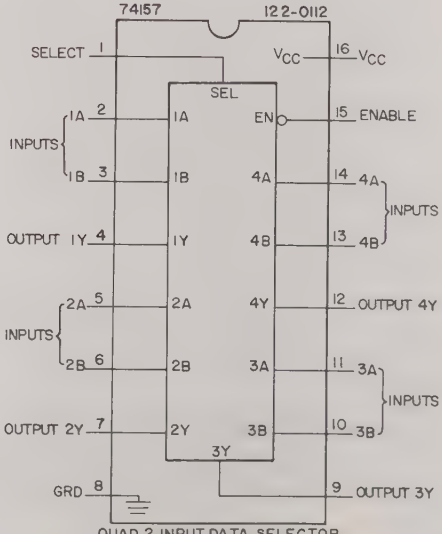

BCD-TO-DECIMAL DECODER




DUAL 4-INPUT NAND GATE

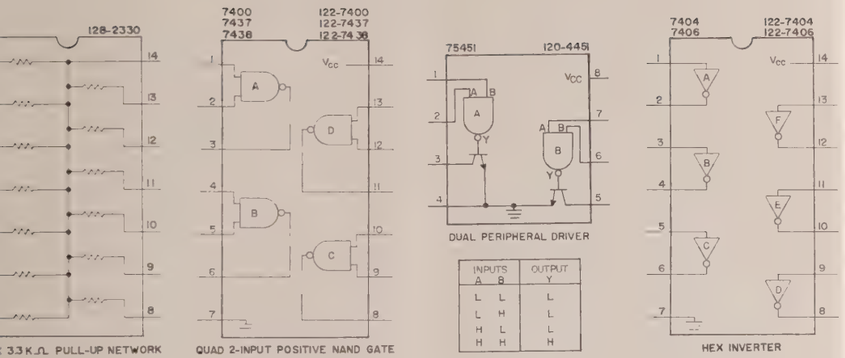



15 X 150 Ω PULL-UP NETWORK




QUAD 2-INPUT DATA SELECTOR

| INPUTS | | | | OUTPUT |
|---|---|---|---|---|
| ENABLE | SELECT | A | B | Y |
| H | X | X | X | L |
| L | L | L | X | L |
| L | L | H | X | H |
| L | H | X | L | L |
| L | H | X | H | H |



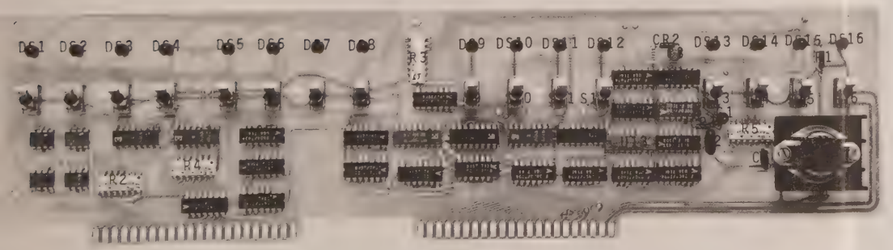




Figure 6-3. Scanner Assembly Component Locations.

NOTES:

1. Unless otherwise noted, all resistor values are in ohms, all capacitor values are in microfarads.

Highest Reference Designations Used

C5 CR2 DS16 R5 S16 U29 VR1

| IC REF DES | IC PART NO. |
|---|---|
| U1 | 122 7437 |
| U2 | 122-7438 |
| U3 | 120-4451 |
| U4 | 120-4451 |
| U5 | 120-4451 |
| U6 | 120-4451 |
| U7 | 122-7400 |
| U8 | 122-7404 |
| U9 | 122-7451 |
| U10 | 122-7404 |
| U11 | 122-0112 |
| U12 | 122-7400 |
| U13 | 122-7442 |
| U14 | 122-7442 |
| U15 | 122-7442 |
| U16 | 122-7442 |
| U17 | 122-7404 |
| U18 | 122-7404 |
| U19 | 122-7404 |
| U20 | 122-7437 |
| U21 | 122-7437 |
| U22 | 122-7437 |
| U23 | 122-7437 |
| U24 | 122-0112 |
| U25 | 122-7404 |
| U26 | 122-7437 |
| U27 | 122-0112 |
| U28 | 122-7437 |
| U29 | 122-7440 |

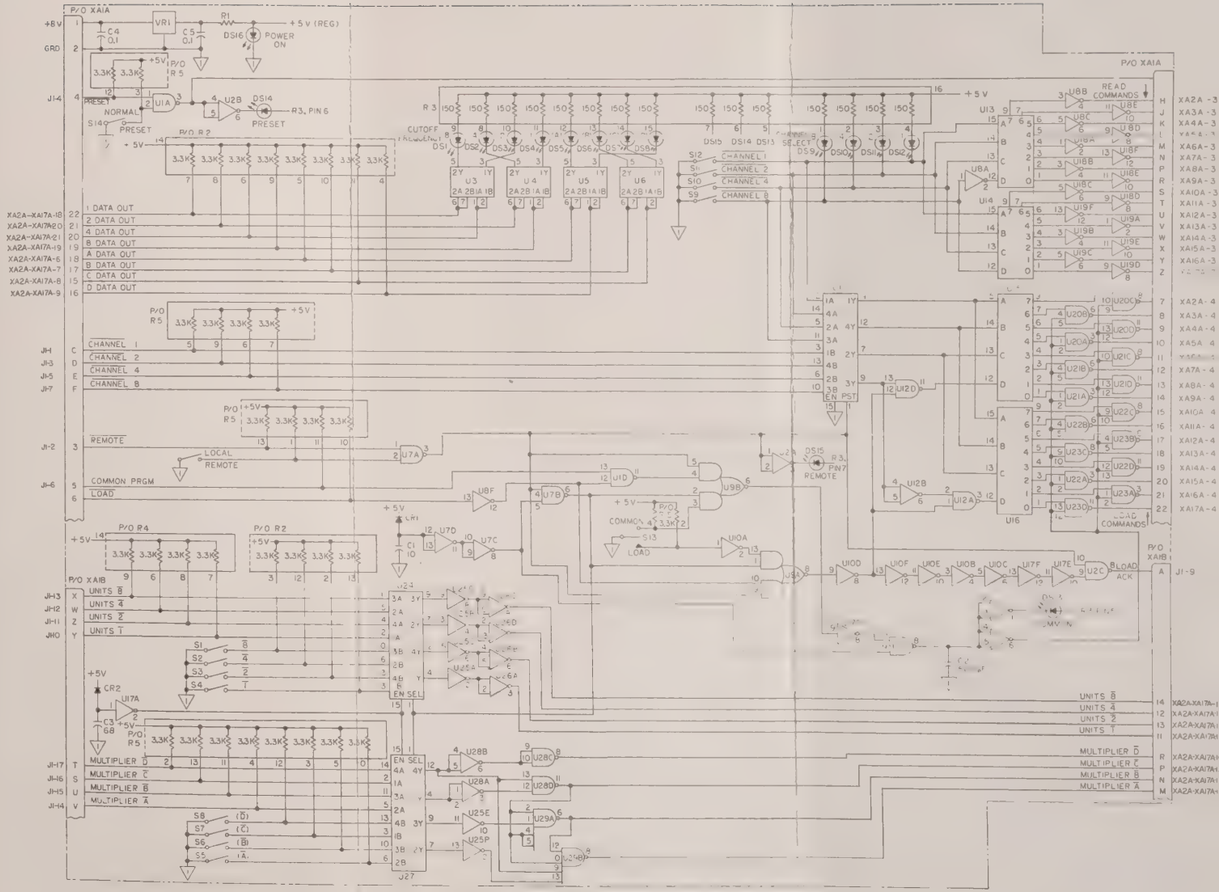
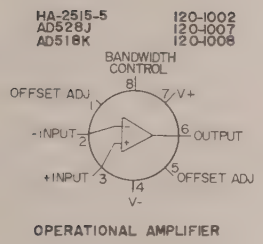
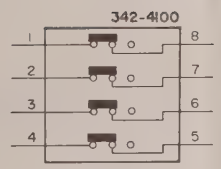


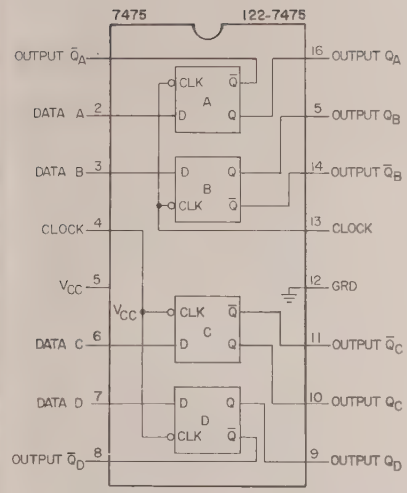

Figure 6-4. Scanner Assembly Schematic.



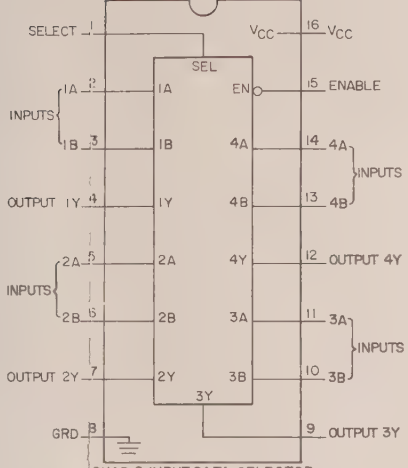
OPERATIONAL AMPLIFIER



(4) SLIDE SWITCH

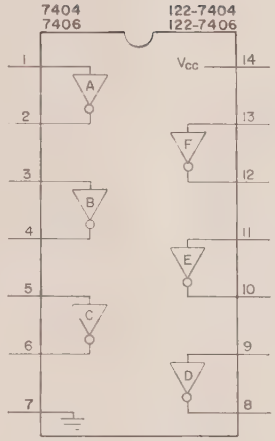


QUAD BISTABLE LATCH

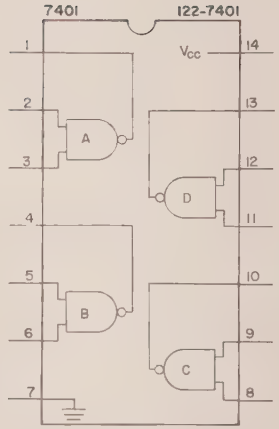


QUAD 2-INPUT DATA SELECTOR

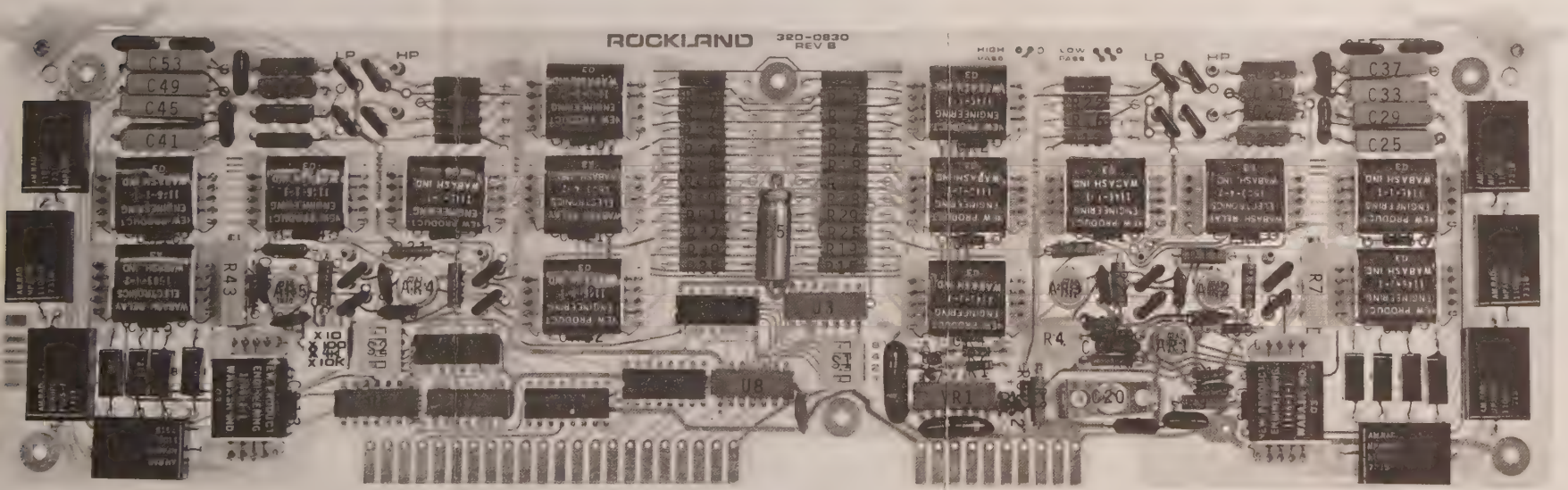
| INPUTS | | | | OUTPUT |
|---|---|---|---|---|
| ENABLE | SELECT | A | B | Y |
| H | X | X | X | L |
| L | L | L | X | L |
| L | L | H | X | H |
| L | H | X | L | L |
| L | H | X | H | H |

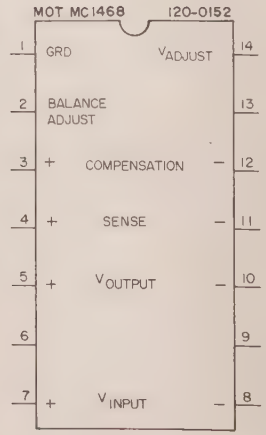


HEX INVERTER



QUAD 2-INPUT POSITIVE NAND GATE, OPEN COLLECTOR



DUAL ±15 VOLT REGULATOR

Figure 6-5. Filter Card Assembly Component Locations.

NOTES:

1. Unless otherwise noted, all resistor values are in ohms, all capacitor values are in microfarads.
2. Component values marked with an asterisk (*) are for Butterworth filter cards, component values marked with a double asterisk (**) are for Bessel filter cards.
3. For type HA-2515-5 op amp, the wiper of R43 is connected to +15V. For type 8007 op amp, the wiper of R43 is connected to -15V.
4. Values for coupling resistors are given in Table 6-1.
5. Jumpers are shown in low-pass configuration, pin A to pin C and pin B to pin D. For high-pass configuration connect pin A to pin D and pin B to pin E. All jumpers must be connected the same way.

Highest Reference Designations Used:

AR5 C61 CR16 K16 R52 S2 U8 VR1

| IC REF DES | IC PART NO. |
|---|---|
| U1 | 122-7475 |
| U2 | 122-0112 |
| U3 | 122-7406 |
| U4 | 122-7475 |
| U5 | 122-0112 |
| U6 | 122-7406 |
| U7 | 122-7401 |
| U8 | 122-7401 |

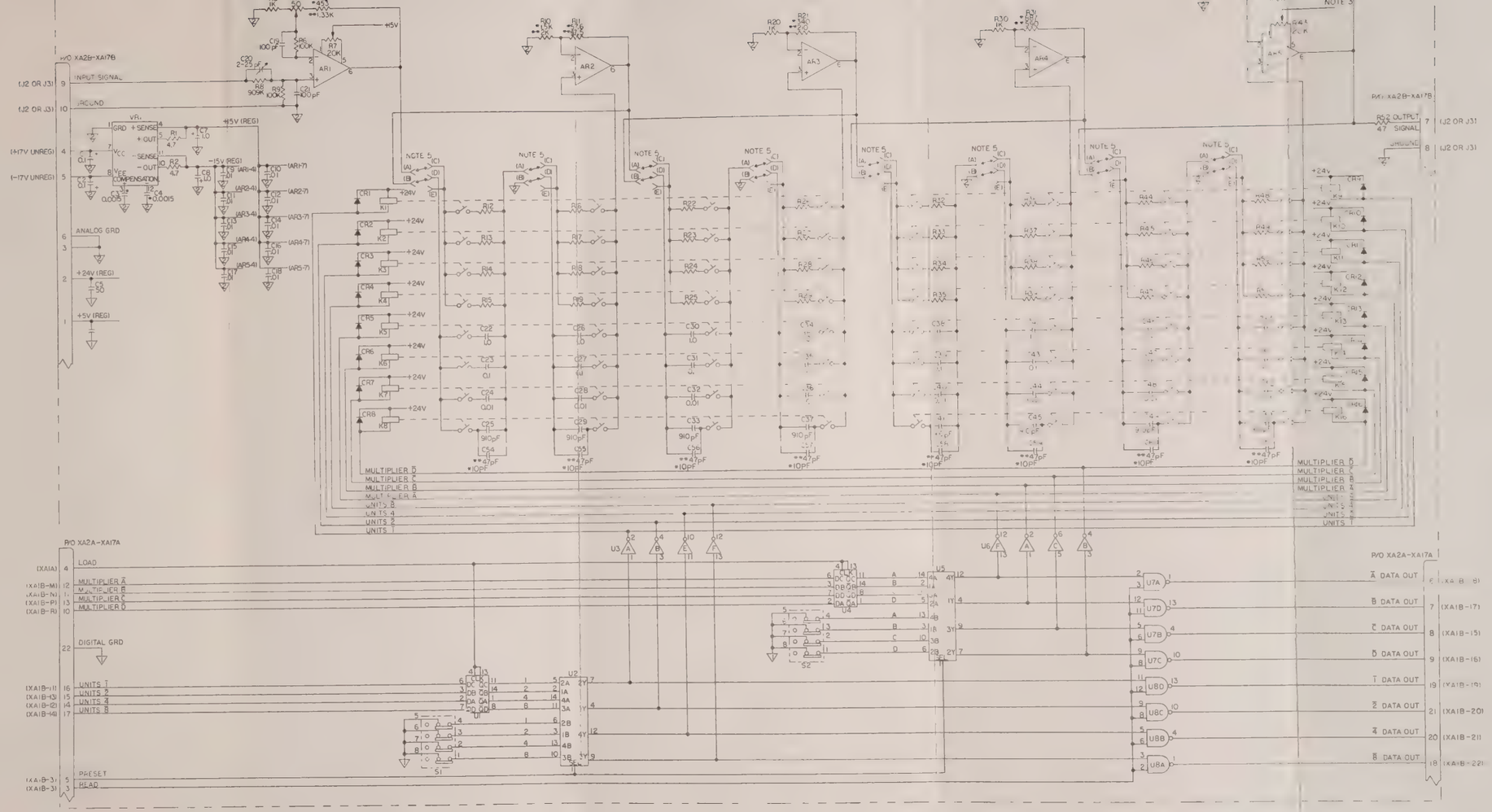



Figure 6-6. Filter Card Assembly Schematic.

MANUAL CHANGES
MULTI-CHANNEL FILTER
SYSTEM 816

Manual Part Number 800-0080

Make all corrections in the manual listed as Errata; check the serial numbers of your SYSTEM 816 and make the changes corresponding to them, according to the table below:

| Mainframe Serial No. | Filter Card Serial No. | Make Changes |
|---|---|---|
| ALL | ALL | Errata |
| | 1252513 & up | 1, 2, 3 |
| 1255301 & up | | 4 |
| | 1257026 & up | 1, 2, 5, 7 |
| | 1258806 & up | 1, 2, 5, 6, 7 |

## Errata

1. On pp. 5-11, 5-15, 5-19, 5-27 and 5-31, change description and Part No. as follows:

| REF DES | DESCRIPTION | PART NO. |
|---|---|---|
| AR2 | IC AMPL: Linear Op Amp 8007 | 120-1009 |
| AR3 | IC AMPL: Linear Op Amp 8007 | 120-1009 |
| AR4 | IC AMPL: Linear Op Amp 8007 | 120-1009 |

2. Add Serial Number Label, Part No. 371-1000 to all Filter Card Parts Lists.

3. On p. 1-8, Table 1-4:

   Change Accuracy to read:
   Accuracy: ± 2%, (±3% in highest multiplier position)

   Change Stability to read:
   Stability: ± 200 ppm °C (typical)

   Change PHASE MATCH BETWEEN FILTER CARDS to read:
   TYPICAL PHASE MATCH BETWEEN FILTER CARDS ±2° or ±2%, whichever is greater.

   Change Noise and Hum (including Crosstalk) to read:
   Noise and Hum (including Crosstalk): 80 dB below full-scale signal with inputs shorted and 100 KHz detector bandwidth.

   Change Drift to read:
   Drift: 0.5 mV/°C, typical

## Change 1

On p. 6-7, Filter Card Assembly Schematic (Fig. 6-6), change R1 and R2 to 10 ohms.

On pp. 5-9, 5-13, 5-17, 5-21, 5-25, 5-29 and 5-33, change R1 and R2 to 10 ohm, 5%, ⅛W, Part No. 116-0101.

## Change 2

Add IC Sockets, Part No. 353-0801 to AR2 thru AR5 on all Filter Card Options.

## Change 3

On p. 6-7, Filter Card Assembly Schematic (Fig. 6-6), add C62, 10pf from pin 8 of AR4 to analog ground. This change applies to Option-01 Filter Cards only. On the Component Location drawing on p. 6-6, this component is located between AR4 and R30.

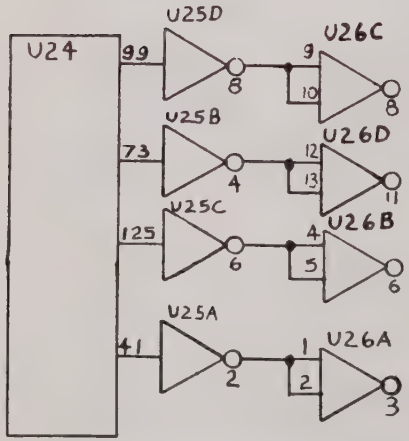
On p. 5-8, Add C62, CAP: Fxd mica dipped 10pf 10% 500 V Part No. 101-0100 to Parts List.

## Change 4

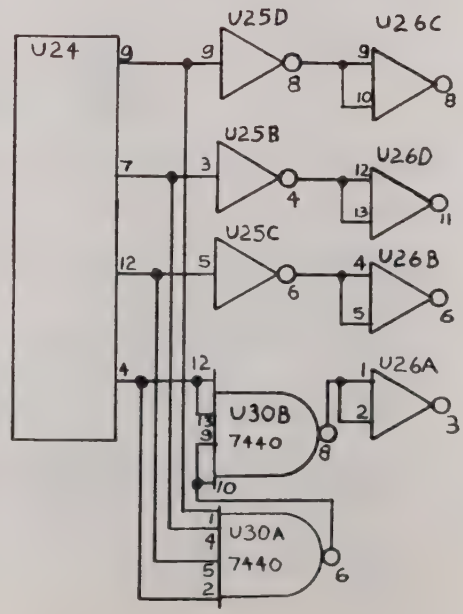
On p. 6-5, Scanner Assembly Schematic (FIg. 6-4), add U30 and make the circuit change shown below. On the Component Location drawing (Fig. 6-3), U30 is located between U26 and U22.

On p. 5-6 add U30, IC: Dual 4-input NAND Buffer, Part No. 122-7440 to Parts List.

FROM




TO



## Change 5

On pp. 5-11, 5-15, 5-19, 5-27 and 5-31, change description and Part No. as follows:

| REF DES | DESCRIPTION | PART NO. |
|---|---|---|
| AR1 | IC AMPL: Linear Op-Amp | 120-1014 |
| AR2 | IC AMPL: Linear Op-Amp | 120-1014 |
| AR3 | IC AMPL: Linear Op-Amp | 120-1014 |
| AR4 | IC AMPL: Linear Op-Amp | 120-1014 |
| AR5 | IC AMPL: Linear Op-Amp | 120-1014 |

On pp. 5-25, 5-29 and 5-33, change description and Part No. as follows:

| REF DES | DESCRIPTION | PART NO. |
|---|---|---|
| R43 | Not used | None |

## Change 6

On p. 5-7, change description and Part No. as follows:

| REF DES | DESCRIPTION | PART NO. |
|---|---|---|
| AR1 | IC AMPL: Linear Op-Amp | 120-1014 |
| AR2 | IC AMPL: Linear Op-Amp | 120-1014 |
| AR3 | IC AMPL: Linear Op-Amp | 120-1014 |
| AR4 | IC AMPL: Linear Op-Amp | 120-1007 |
| AR5 | IC AMPL: Linear Op-Amp | 120-1007 |

On p. 5-23, change description and Part No. as follows:

| REF DES | DESCRIPTION | PART NO. |
|---|---|---|
| AR1 | IC AMPL: Linear Op-Amp | 120-1014 |
| AR2 | IC AMPL: Linear Op-Amp | 120-1007 |
| AR3 | IC AMPL: Linear Op-Amp | 120-1007 |
| AR4 | IC AMPL: Linear Op-Amp | 120-1007 |
| AR5 | IC AMPL: Linear Op-Amp | 120-1007 |

On p. 5-9, change description and Part No. of R43 and add R54 as follows:

| REF DES | DESCRIPTION | PART NO. |
|---|---|---|
| R43 | RES:Var cermet 200K 10% 3/4W | 118-4200 |
| R54 | RES:Fxd metflm 200K 1% 1/10W | 113-2001 |

On p. 6-7, Filter Card Assembly Schematic (Fig. 6-6) R54 is connected to the wiper of R43; NOTE 3 should be changed to read as follows:

NOTE 3. For Part No. 120-1014 Op-Amp R43 is 20K and the wiper is connected to +15V. For Part No. 120-1007 Op-Amp R43 is 200K and the wiper is connected to +15V through a 200K resistor. R43 is not used on Filter Card Options 05, 06 and 07.

On p. 6-7, Filter Card Assembly Schematic (Fig. 6-5) add C63, 47pf from pin 2 to pin 6 of AR5. This change applies to Option-01 Filter Cards only.

On p. 5-8, add C63, CAP: Fxd mica dipped, 47pf 10% 500V Part No. 101-0470.

Change 7

On p. 1-8, Table 1-4:

Change DC Offset to read:
DC Offset: 0 ±10 millivolts at any $f_c$ setting.

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